This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

KSG 461

Boston Society of Natural History.

From

Received

TRANSACTIONS

OF THE

PHILOSOPHICAL AND LITERARY SOCIETY

OF

LEEDS,

CONSISTING OF PAPERS READ BEFORE THE SOCIETY.

VOLUME I.—PART I.

LONDON:

LONGMAN, REES, ORME, BROWN, GREEN, AND LONGMAN;

J. Y. KNIGHT, 39, BRIGGATE, LEEDS.

1837.

△
KSG 461

HARVARD COLLEGE LIBRARY
INGRAHAM FUND
MAY 4 1945

LEEDS:
PRINTED BY ANTHONY PICKARD, TOP OF BRIGGATE.

CONTENTS.

PAGE.

Introduction, ... v.

I.—*On the Bed of the Mississippi.* By the late John Luccock, Esq. 1

II.—*On the Varieties of Water.* By William West. 15

III.—*A Description of the Internal Structure of various Limaces, found in the Neighbourhood of Leeds.* By Thomas Nunneley..... 41

IV.—*Abstract of a Notice of certain Roman Coin Moulds, found at Lingwell-Gate, near Wakefield, in* 1820. By John Hey, F. L. S. F. G. S. 80

V.—*On the Anatomy of Actinia Coriacea.* By Thomas Pridgin Teale. 91

VI.—*On Alcyonella Stagnorum.* By T. P. Teale. 116

VII.—*On the Yorkshire Coalfield.* By the late Edward S. George, F. L. S. 135

INTRODUCTION.

The establishment of the Leeds Philosophical and Literary Society, like many other undertakings of great public ornament and utility but of small pecuniary profit, seems to have been in some degree a consequence of the permanent restoration of peace in the year in 1815: the population, the opulence, and the intelligence of the town of Leeds, had long been such as to supply ample materials for an efficient scientific re-union, and the project by whomsoever started in 1818 met with that immediate support from many quarters, which renders it impossible, except at the risk of mistake, to single out any individuals as the first proposers or original supporters of the Institution. One point is likely to be but little disputed; though literary and scientific associations formed on a temporary basis, had doubtless existed from time to time in many parts of the kingdom; indeed, there was one in this town so early as 1783, of which the late Mr. Hey and Dr. Priestley were leading members; yet with the exception of Manchester, Liverpool, and Norwich, it is doubtful if the Philosophical and Literary Society of Leeds, was not one of the earliest provincial associations in the kingdom, which was invested with

a permanent character by the devotion of a considerable capital to the purposes of the Institution.

The undertaking was introduced to the public at a meeting, held at the Court-House, in Leeds, November 11th, 1818, the late William Hey, Esq., in the Chair. The following Resolution was unanimously adopted as the basis of the proposed Society, with an obvious view to avoid those points of difference, which it is understood, had caused the dissolution of the earlier association.

"At a Meeting of Gentlemen who favour the "formation of a Philosophical Institution for Leeds "and its Vicinity, held December 11th, 1818, in "the Court-House, Leeds;

"MR. HEY, IN THE CHAIR:

"IT WAS RESOLVED UNANIMOUSLY,

"That this Institution shall be denominated The "Philosophical and Literary Society of Leeds, in "which subjects shall be discussed, that include all "the branches of Natural Knowledge and Literature, "(strictly so called) but excluding all topics of Re-"ligion, Politics, and Ethics.

The first stone of the building was laid on the Ninth of July, 1819, the architect being Mr. Richard Dennis Chantrell; the first officers and council were elected on the Fifth of November, in the same year. The total cost of the Building exceeded £6100.: a list of the original members is subjoined.

The laws of the Society were finally enacted at a general meeting, held January 14th, 1820, and the regular proceedings of the Society were opened the Sixth of April, 1821, with an introductory paper

written by the late Mr. Charles Turner Thackrah, which the council had selected by ballot out of three which were proposed as introductory essays.

The Nucleus of the Museum was formed by many valuable donations, the most important of which seems to have been the Collection in Natural History presented by the late Mr. Atkinson, F.L.S. the curator and librarian. It appears from early documents that a library was considered one of the primary features of the Institution.

During the interval between the sixth and seventh sessions (1826—1827) the last alterations in the building were commenced under the direction of the Building Committee, by Messrs. Watson and Pritchett, of York: these were completed in the course of the ensuing year at an expense of £1300.

In the eighth session (1828) one of the secretaries, Mr. William Osburn, jun., F.R.S.Lit. drew up an account of the Mummy presented by Mr. Blayds. This report was printed and published for the Society.

During the interval between the formation of the Society and its opening, a temporary association was established, before which the following papers were read:—

1819.

Nov. 26.—On the Effects of Spirituous Liquors on the Human Frame; by Mr. Atkinson, East Parade.

Dec. 10.—The Destruction of Herculaneum and Pompeii; by Mr. John Atkinson, Surgeon.

On some Colours for Painting found at Pompeii; by Mr. West.

24.—On the Comparative Merits of Literature and Natural Philosophy; by Mr. Joseph Atkinson.

1820.

Jan. 7.—The Crusades; by Mr. Edward Baines, jun.

On Substances from which a Blue Precipitate might be procured by means of Heat; by Mr. West.

21.—On Vision; by Mr. R. C. Battye.

Feb. 4.—On Iodine; by Mr. West.

18.—On the Formation of Prussian Blue from various substances; by Mr. E. S. George.

March 1.—On Icebergs; by Mr. Thomas Blayds.

On the Membrana Nictitans in the Eyes of Sheep and Horses, by Mr. C. T. Thackrah.

15.—On the Whiteness of Snow; by Mr. John Cadman.

April 13.—On Chemical Terms; by Mr. E. S. George.

May 13.—On the best means of preserving Health; by Mr. John Jowitt.

29.—On the best means of acquiring Knowledge; by Mr. Luccock.

Dec. 9.—On the Origin of Commerce; by Mr. Lupton.

On the relative Happiness of Cultivated Society and Savage Life; by John Marshall, Esq.

1821.

Jan.—On the Mental Powers; by Mr. Sangster.

Jan. 26.—On the Laws of Solon and Lycurgus; by Mr. Shaw.

Since the opening of the Society the following papers have been read.

GENERAL MEETINGS.

1821.

April 6.—The Introductory Essay; by Mr. C. T. Thackrah.

27.—On the Nature and properties of the Atmosphere; by Dr. Hunter.

May 4.—On the Atomic Theory; by Mr. West.

Nov. 2.—On Sleep; by Dr. Williamson.

16.—Some Observations on Natural History; by Mr. Luccock.

Dec. 7.—On Geology; by Mr. Marshall.

21.—On the different Theories of the Earth; by Dr. Hunter.

1822.

Jan. 4.—On Craniology; by Dr. Milligan, of Edinburgh.

Jan. 18.—On the Uses of Intellectual Philosophy; by the Rev. R. W. Hamilton.

Feb. 1.—On the Instinct of the lower Animals; by Mr. Sangster.

15.—On the Termination of the River Niger; by Mr. William Osburn, jun.

March 1.—On Money; by Mr. Richard Barrett Watson.

15.—On the Nature and Use of the Science of Geology; by Dr. Gilby, of Wakefield.

April 5.—On the Rise and Progress of Art, Science, and Literature, among the Athenians; by Mr. Edward Baines, jun.

19.—On the Oldham Spa Water; by Dr. Walker, of Huddersfield.

May 3.—On the Geology of the Neighbourhood of Leeds; by Mr. E. S. George.

17.—On the Discoveries that have been made by means of Glass; by the Rev. Joseph France, of Silcoates, near Wakefield.

Nov. 1.—On Taste; by Mr. William Spear, of Edinburgh.

15.—On Iodine; by Mr. West.

Dec. 6.—On the Geology of the Beds above the Chalk in Yorkshire; by Mr. E. S. George.

An Analysis of the Huddlestone and Fairburn Limestones; by Mr. E. S. George.

A Notice on the Ignition of Charcoal by the Galvanic Battery; by Mr. West.

20.—On Coloured Shadows; by William Hey, Esq.

1823.

Jan. 3.—On Meteorology; by Mr. J. G. Marshall.

17.—On the History and Prospects of the Human Species considered in relation to Intellectual and Social Improvement; by the Rev. R. W. Hamilton.

Feb. 7.—On the Origin of the South Sea Islanders; by Mr. William Osburn, jun.

21.—On a Mechanical Theory of the Fluctuations of the Barometer, and of the Origin of uncertain Winds which prevail in the Temperate and Frigid Zones; by Mr. John Gough, of Kendal.

March 7.—On Modern English Literature; by James Montgomery, Esq., of Sheffield.

21.—On the Effect of Atmospheric Changes on the Health and

Spirits, particularly on the Old Insane; by Dr. Allen, of York.

April 4.—On the Influence of Lord Bacon's Philosophical Speculations in promoting the Progress of Experimental Science; by Dr. Williamson.

18.—On the Elgin Marbles, and the Causes of the Excellence of Grecian Sculpture; by Mr. Edward Baines, jun.

May 2.—On Genius—its various periods of manifestation, and a few of its striking Characteristics; by Mr. R. B. Watson.

16.—On the Great Cave of Kentucky, usually called the Mammoth Cave; by Mr. Luccock.

Nov. 7.—On the Source and Evolution of Heat in Animals; by Mr. T. P. Teale.

21.—On the Natural Divisions of Insanity, and on the question —How far the mind retains or exhibits its former individuality of Character, and how much it is altered, and the kind, and degree, and mode of that Alteration; by Dr. Allen, of York.

Dec. 5.—On Atmospheric Refraction; by Mr. John Atkinson, jun. Solicitor.

19.—On the Utility of Mental and Corporeal Exertion; by Mr. John Atkinson.

1824.

Jan. 2.—On the Production of Wealth, and on the propriety of discussing subjects of Political Economy as distinguished from Politics; by John Marshall, Esq.

16.—On the Origin of Language, and on the Origin and Progress of Alphabetical Writing; by G. S. Weidemann, Esq. of Ripon.

Feb. 5.—On Poetry; by the Rev. Thomas Greenwood.

29.—On the Classification, distinguishing Characters, and Analogy of Natural Beings; by Mr. John Atkinson, (Curator.)

March 5.—On the Inhabitants of the Arctic Regions; by Mr. William Osburn, jun.

19.—On the Condition of the Settlements in the Western parts of America, and on Emigration generally to that Country; by B. Rotch, Esq., Barrister-at-Law.

April 2.—On Cambodunum, and on the late Discoveries at Slack, near Huddersfield; by Dr. Walker, of Huddersfield.

23.—An Enquiry as to the Nature and Operations of the Moral

Faculty in Man; by David Bogue, Esq. A.M. of the Inner Temple.

May 7.—On some points connected with Poetical Composition; by G. S. Weidemann, Esq., of Ripon.

21.—A General Retrospect of Literature from the earliest Period to the Middle Ages; by James Montgomery, Esq. of Sheffield.

Nov. 5.—A Retrospect of Philosophical Societies, and some Considerations on their peculiar Advantages; by Dr. Williamson.

19.—On the Bed of the Mississippi; by Mr. Luccock.

Dec. 3.—On the Philosophy of Names; by the Rev. Robert Humphreys, of Bramley.

17.—On Coal Plants, and the Origin of Coal; by Mr. John Phillips, of York.

1825.

Jan. 7.—On the Physiology of Plants; by Mr. T. P. Teale.

21.—An Essay on the Question—How far Poetical Views are compatible with strict Justice; by Mr. Yorke.

Feb. 4.—On the Revival of Literature in Italy, in the Fourteenth Century; by James Entwistle, Esq.

18.—On Mental Originality; by Mr. West.

March 4.—On Personal Identity; by the Rev. R. W. Hamilton.

18.—On Painters and Painting from the time of the Accession of Henry VIII. to the death of Charles I.; by Francis Thomas Billam, Esq.

April 8.—On the Principles of Population in Connection with the Poor Laws; by Michael Thomas Sadler, Esq.

May 6.—On the best means of improving the Condition of the Poor in large Towns; by Michael Thomas Sadler, Esq.

20.—On the Objects of Captain Franklin's Northern Expedition; by Dr. Traill, of Liverpool.

Nov. 4.—On the mutual Relations subsisting amongst the several Sciences; by S. Bailey, Esq., President of the Sheffield Philosophical Society.

18.—On the Connection between Instinct and Reason; by Mr. R. Taylor, Surgeon.

Dec. 2.—On Craniology; by the Rev. R. W. Hamilton.

16.—On the Knowledge possessed by the Ancients on the Subject of Mineralogy; by the Rev. W. H. Bathurst, A.M.

1826.

Jan. 5.—On the Present State of Education in England, considered as a Preparation for Active Life; by John Marshall, Esq. M.P.

19.—On the State of Science amongst the Arabians during the Middle Ages; by Mr. John Sangster.

Feb. 3.—On the Fossils discovered in the Neighbourhood of Huddersfield; by Dr. Walker.

On the Roman Antiquities of Nismes, in Languedoc; by Dr. Williamson.

17.—On the Philosophy of Music; by William Hey, Esq.

March 3.—On the Philosophy of Music, (second part,) by William Hey, Esq.

17.—On the Philosophy of Ancient Names; by the Rev. Robert Humphreys, A.B.

April 7.—On Marriage Customs; by Benjamin Rotch, Esq., Barrister-at-Law.

21.—On the Advantages of Classical Education; by the Rev. Joseph Hutton, LL.D.

May 5.—On Stained Glass and Glass Stainers, from the Invention of the Art to the present Time; by Francis Thomas Billam, Esq.

19.—On the Principles of Early Education, particularly in reference to the Formation of Infant Schools; by Dr. Williamson.

Nov. 3.—The Twentieth Century, (in verse); by Mr. West.

17.—On the Varieties of the Human Race; by R. M. Fawcett, M.D.

Dec. 1.—On the Revival of Learning in Italy; by J. Entwistle, Esq.

15.—On the Limits of Human Knowledge; by the Rev. W. H. Bathurst, A.M.

1827.

Jan. 5.—On the Functions of the Brain; by Mr. Wildsmith.

19.—On the Origin and History of Printing, with some Account of the most celebrated Printers, and of the principal Public Libraries of Europe; by Mr. E. Baines, jun.

Feb. 2.—On the Necessity, the Wisdom, and Glory, of cherishing a National Spirit in the Patronage of the Fine Arts, and a National Pride in the excellence of British Artists; by William Carey, Esq., London.

Feb. 16.—On the Anatomy of Expression in Painting and Sculpture; by Mr. John Hey.

March 2.—On the Signs of Inns and Shops; by Francis Thomas Billam, Esq.

16.—On Egypt—its former Magnificence and Antiquities, Manners and Customs, &c. &c.; by John George Wood, F.S.A., London.

April 6.—On the Philosophy of Names; by the Rev. Robert Humphreys.

20.—On the Mechanical Effect of Rain, Rivers, and the Sea, and on the Materials which compose the Surface of our Planet; by Mr. John Phillips, York.

May 4.—On Egyptian Mummies; by Mr. William Osburn, jun.

18.—On the Discovery of Crystals of Pyrites, in some old blocks of wood, dug up at Whitby; by the Rev. George Young, A.M., Whitby.

On the Principles which should guide us in the Choice of our Intellectual Pursuits; by the Rev. Joseph Hutton, LL.D.

Nov. 2.—On the Imperfections of Language; by the Rev. W. H. Bathurst, A.M.

16.—On the Balance of the Numbers and Food of Animated Beings; by M. T. Sadler, Esq.

Dec. 7.—On Sensation in Animals; by Mr. John Phillips, F.G.S., York.

21.—On Gypsies; by Mr. John Atkinson, jun.

1828.

Jan. 4.—On the History and Uses of Telegraphs; by Mr. Edward Baines, jun.

18.—On the Moral Influence of History; by the Rev. G. S. Weidemann.

Feb. 1.—On the Origin of Poetry; by Mr. Donald M'Farlane.

15.—On the Eastern Origin of Mankind, and their Primary Dispersion over the Earth; by Rowland Morris Fawcett, Esq., Cambridge.

March 7.—On the Progress of Painting from the death of Charles the Ist. to the close of the Reign of George II.; by Francis Thomas Billam, Esq.

21.—On the Advantages to be derived from Mathematical and Philosophical Knowledge; by Mr. John Darby.

April 11.—A Communication describing the situation in which some Fossil Remains of Elephants had been discovered on the Norfolk Coast; by Mr. Samuel Woodward, F.G.S. of Norwich.

On Apparitions; by Mr. William Hey, jun.

25.—On the Colour of the Sky, and the Relation subsisting between Solar Light and the Light of Combustion; by Dr. Dalton, F.R.S., &c., Manchester.

May 2.—On Coincidences; by Francis Thomas Billam, Esq.

16.—On the Poetry of Goldsmith; by M. T. Sadler, Esq.

Oct. 24.—On the Progress of Ancient Civilization; by M. T. Sadler, Esq.

Nov. 7.—On the Geology of Yorkshire; by Mr. E. S. George, F.L.S.

21.—On the Character and Condition of Women in various Ages and Countries; by Francis Thomas Billam, Esq.

Dec. 5.—On the Physical Modes of Matter; by Alexander Taylor, M.D.

19.—On Omens; by Richard Atkinson, Esq., Barrister-at-Law.

1829.

Jan. 2.—On the Origin of Merchants' Marks; by Mr. S. Woodward, F.G.S. of Norwich.

On the System of Numerical Notation, and on the Calendar of the Ancient Egyptians; by Mr. William Osburn, jun.

16.—On the Uses and Abuses of Hypothesis in Science; by James Williamson, M. D.

Feb. 14.—On the Origin of Gothic Architecture; by Mr. John Sangster.

18.—On Meteors and Meteoric Stones; by Mr. Joshua Dixon.

March 6.—On the Metamorphoses of Insects; by Mr. H. Denny.

20.—On Armorial Bearings; by Mr. John Wilkinson.

April 3.—A Discussion upon Civilization.

24.—On the Origin of Written Characters; by Mr. William Osburn, jun.

Oct. 23.—On Synonyms; by the Rev. R. W. Hamilton.

Nov. 6.—On the Varieties of Water; by Mr. W. West.

20.—On the Advantages of Civilization to Mankind, and on the possibility of promoting it by simple and direct methods; by Luke Howard, Esq. F.R.S.

Dec. 4.—On the Logic of Aristotle; by Samuel Bailey, Esq. of Sheffield.

18.—On Digestion in Animals; by Mr. John Phillips, of York.

1830.

Jan. 1.—A Review of the Progress of Classical Literature, as connected with some of the Universities and Literary Establishments in Europe; by the Rev. John Dodsworth, A.M.

15.—On the Necessity for Exertion as promoting the progress of Civilization; by M. T. Sadler, Esq. M.P.

Feb. 5.—On the German Literature of the Eighteenth Century; by James Entwisle, Esq.

19.—On the Moral Influence of Free Trade; by Mr. Edward Baines, jun.

March 5.—On the History and Antiquities of Churches in England; by Francis Thomas Billam, Esq.

19.—On the Tune and Rhythm of the Human Speech; by Mr. John Wilkinson.

April 2.—On the Nature and Extent of Mathematical Evidence; by the Rev. William Turner, of Halifax.

16.—On the Choice of Subjects of Study; by the Rev. Joseph Hutton, LL.D.

Oct. 22.—On the Decline of the Roman Empire as related by Gibbon; by Mr. William West.

Nov. 5.—An Enquiry how far the lower orders of Animals are capable of exercising Reason; by Mr. Henry Denny.

19.—On the Application of Mathematical Reasoning to Metaphysical and Moral Science; by the Rev. James Acworth, A.M.

Dec. 3.—On National and Individual Character, as modified by external Causes; by Adam Hunter, M.D.

17.—On some of the Causes which have principally influenced the progress of Literature and Science in this Country; by M. T. Baines, Esq. Barrister-at-Law.

1831.

Jan. 17.—On the Antiquity of Warm Bathing in England; by J. K. Walker, M.D. of Huddersfield.

On the Boiling point of Water under certain circumstances with Memoranda of Experiments; by Mr. William West.

Jan. 17.—An Abstract of a Meteorological Register kept at Ackworth School for 1830; by Luke Howard, Esq. F.R.S.,

21.—On the History of Penal Institutions, illustrated by the Criminal Law of Athens; by Robert Hall, Esq. Barrister-at-Law.

Feb. 4.—On the Advantages of a regulated and permanent System of Emigration; by James G. Marshall, Esq.

18.—A Notice of some Roman Coin Moulds, in the Museum of of the Society, found at various times at Lingwell-Gate near Wakefield; by Mr. John Hey, (Curator.)

March 5.—On the probable Results of the present State of Science; by Mr. J. H. Whitehead.

19.—On the Phenomena of Suspended Animation; by J. P. Kaye, M.D., of Manchester.

April 8.—On the Yorkshire Dialect; by the Rev. R. W. Hamilton.

22.—On the Alleged Influence of certain Occult and Preternatural Causes on the Corporeal Functions, especially in reference to the Subject of Modern Miracles; by James Williamson, M.D.

Oct. 21.—On Vapours; by William Hey, Esq.

Nov. 4.—On Ceremonial Magic; by Mr. William Osburn, jun.

18.—On the Natural History, Devastations, and Uses of Locusts; by Mr. Henry Denny.

Dec. 2.—A Phrenological Analysis of the Theory of Dreams, Spectral Illusions, and some of the more usual Phenomena of Mental Derangement; by Dr. Alexander, of Wakefield.

16.—On the Improved Means afforded by the progress of Knowledge, of elucidating the History of the Past, and on the Importance of such Elucidation, in reference to the Future Prospects of Society;—Part 1st. by the Rev. —— Taylor, of Manchester.

1832.

Jan. 6.—On the Distribution of Animals over the surface of the Globe; by Richard Matthews, Esq. Barrister-at-Law.

20.—The Conclusion of the Rev. Mr. Taylor's Paper.

Feb. 3.—On Presentiments and First Impressions; by Mr. Robert Baker.

Feb. 17.—On several of the Incidents of Vitality, including Suspended Animation, and Spontaneous Combustion; by Mr. William Wildsmith.

March 2.—On the Comparative Beauties of Grecian and Gothic Architecture; by Mr. Christopher Kemplay.

16.—On Poetry—the early English Poets; by Mr. Robert Perring.

April 6.—On the Philosophical Opinions of Bishop Berkeley, and especially on the Non-existence of a Material World; by Mr. John Wilkinson.

27.—On the Origin and Progress of the Ascetic Life, and of its Effects upon the Social System of Europe; by Mr. George Waring.

Oct. 19.—On Vapours; by William Hey, Esq.

Nov. 2.—On the Happiness of Man, as depending on the proper adjustment of his Mental and Bodily Powers; by Disney Launder Thorp, M.B.

16.—On Home Colonization; by Mr. William Atkinson.

Dec. 7.—On the Uses of Gelatine, as applied to Human Sustenance; by Sir John Byerley, of London.

21.—Miscellaneous Chemical Observations, with Experiments; by Mr. William West.

1833.

Jan. 4.—On the Influence of the Extension and Improvement of Machinery, particularly with reference to its Effects on the Wages of Labour and the Condition of the Lower Classes; by Mr. John Arthur Ikin.

1833.

Jan. 18.—On Perpetual Motion, the Transmutation of Metals, and the Royal Road to Learning; by Mr. Christopher Kemplay.

Feb. 1.—On the Intellectual Capacity of the Negro; by Mr. William West.

15.—On the Yorkshire Dialect; by the Rev. R. W. Hamilton.

March 1.—On Credulity; by Adam Hunter, M.D.

15.—Observations on the Cause and Increase of Crime; with suggestions for an Alteration in the Laws respecting Prison Discipline and Colonial Transportation; by Mr. Edwin Eddison.

March 29.—The Union of Literature with the Pursuits of Commerce, as exemplified in the Life and Character of the late Mr. Roscoe; by Mr. Hartley Coleridge.

April 19.—On the History of Penal Institutions, as illustrated by the Criminal Law of Rome; by Robert Hall, Esq. Barrister-at-Law.

Oct. 18.—On the Recent Improvements in Science; by James Williamson, M.D.

Nov. 1.—On the Theory of Intellectual Education; by Mr. William Wildsmith.

15.—On the Importance of a Knowledge of Natural History, in the Common Affairs of Life; by Mr. Henry Denny.

Dec. 6.—On the Influence which Literature and the state of Society and Manners exercise upon each other; by Mr. George Waring.

20.—On the Objects and Advantages of Political Economy, with a Sketch of the Present State of the Science; by Mr. John Arthur Ikin.

1834.

Jan. 3.—On the History of the Art of Music, from the earliest periods; by Mr. Charles Cummins.

17.—On the Music, Painting, and Sculpture in Churches; by the Rev. Thomas Kilby, of Wakefield.

Feb. 7.—On the early History and Ruins of Babylon; by Mr. W. A. Jackson.

21.—On the Philosophy of Amusement, or Importance of a Cultivation of Imagination and Taste, duly proportioned to that of the Understanding and Moral Sense; by J. G. Marshall, Esq.

March 7.—On Domestic Architecture from the invasion of Julius Cæsar to the reign of Elizabeth; by Mr. J. Harper, of York.

21.—A Consideration of some questions connected with the Natural History of Man; by Mr. Nunneley.

April 4.—On German Literature; by Mr. Marcus.

18.—On the Literature of the Middle Ages; by H. J. Gainsford, Esq. of Sheffield.

Oct. 17.—An Account of the Meeting of the British Association at Edinburgh; by Mr. William West.

Nov. 7.—On certain Modern English Poets; by Mr. W. A. Jackson.

21.—On the General Improvement and Prosperity of Leeds, as affected by the Smoke of the Factories; with some remarks on the means of abating the Nuisance; by Mr. Christopher Kemplay.

Dec. 5.—On the Anatomy of Actinia Coriacea; by Mr. T. P. Teale.

19.—On the Study of Geology; by Robert Hall, Esq. Barrister-at-Law.

1835.

Jan. 2.—On the Origin of the English Language; by Dr. Wright, of Wakefield.

16.—On Leeds and its Improvements; by Adam Hunter, M.D.

Feb. 5.—An Appeal from Musicians to First Principles, in behalf of Vocal Music; by Mr. John Wilkinson.

20.—The concluding part of Mr. Wilkinson's Paper.

March 6.—On the Imperfection of the Musical Scale; in reply to a Paper lately read before the Society; by William Hey, Esq.

20.—On the Isiac Mysteries; by the Rev. R. W. Hamilton.

April 3.—On the Motions of Bodies generally acted upon by Forces tending to a Point, and particularly with reference to the Solar and Lunar Theories; by the Rev. Joseph Holmes, A.M.

24.—On the Literature of the Middle Ages; by H. J. Gainsford, Esq. of Sheffield.

Oct. 16.—On the Inequalities of the Moon's Orbit, occasioned by the disturbing Influence of the Sun; by the Rev. Joseph Holmes, A.M.

Nov. 6.—The concluding Part of the above Paper.

15.—On the Economy of Nature as exemplified in the First Principles of the Material World; by Mr. William Wildsmith.

Dec. 4.—On the Rise and Progress of the Leeds Philosophical and Literary Society; by Robert Hall, Esq. Barrister-at-Law.

18.—On the Study of History; by Professor Smyth of Cambridge.

1835.

Jan. 1.—On the Philosophy of History; by Adam Hunter, M.D.

15.—On the Classical Period of Greece, compared with the Revival of Letters in Modern Europe; by Mr. H. J. Marcus.

Feb. 5.—On Botanical Geography; by Mr. John Hey.

19.—On Judicial Astrology; by Mr. William Osburn, jun.

March 4.—On the Adaptation of the Atmospheric Constitution to the Physical Condition of Man; by Mr. M. Hall.

18.—On Geological Climate; by Mr. John Hey.

April 1.—On certain recent Metaphysical Speculations; by Mr. W. A. Jackson.

15.—On the Scientific Principles of Locomotion by Railways; by Mr. J. G. Marshall.

1836.

Oct. 21.—On the Origin and Progress of the Ancient Greek Tragedy; by the Rev. Joseph Holmes, A.M.

Nov. 4.—On Education and the Educational Wants of the Town of Leeds; by Mr. Suliot.

18.—A Critical Analysis and Comparison of the Il Bruto Secondo of Alfieri and the Julius Cæsar of Shakespeare; by the Rev. C. Wicksteed, A.B.

Dec. 2.—On the Origin of the Ancient Britons; by Mr. Edward Nevins.

16.—On the Philosophy of Opinion; by Mr. W. Wildsmith.

1837.

Jan. 6.—On the Messenian Wars; by Mr. W. A. Jackson.

20.—Thoughts on Education; by Mr. John Atkinson.

Feb. 3.—On the Influence of Climate and Local Circumstances on the Imagination; communicated by Mr. William Hey, jun.

17.—On Chemical Notation, Isomorphism, and Isomerism; by Mr. William West.

March 3.—On the Sources and Grounds of History; by the Rev. R. W. Hamilton.

17.—On the Comparative Advantages of a State of Civilization and Literature over a State of Barbarism; by Mr. H. J. Marcus.

April 21.—On the Highlands and the Present Condition of the Inhabitants; by Adam Hunter, M.D.

PRIVATE MEETINGS.

1833.

Dec. 25.—On the Reciprocal Transmission of Fluids through Membranous Tissues; by James Williamson, M.D.

On the Presence of Sulphur in certain Metals, and on the Impurity of Hydrogen Gas; by Mr. William West.

Jan. 31.—On the Inverted Position of Objects of Vision upon the Retina; by Mr. William Wildsmith.

On the question, How far are Animals capable of resisting the deprivation of Air and Food; by Francis Thomas Billam, Esq.

April 11.—On the Nature of Thermometric Indication; by Mr. J. H. Whitehead.

Hints in support of the Materiality of Caloric; by Mr. William West.

Further Observations on the Ruins of Babylon; by Mr. William Armitage Jackson.

1834.

Nov. 14.—On the Anatomy of Limaces, with a separation of them into distinct Species, founded on their internal Organization; by Mr. Nunneley.

On the Temperature of the Tunnel of the Leeds and Selby Railway; by Mr. William West.

Dec. 12.—On the Practicability of delineating the Modulations of the Voice in Speech, by a System of Musical Notation; by Mr. John Wilkinson.

Jan. 9.—On the Supposed Connection between Odours and Miasmata; by Mr. William Wildsmith.

Feb. 13.—Remarks communicated by Charles Waterton, Esq., of Walton Hall, on certain statements relating to the Rattle Snake; made by Mr. Audubon in Jameson's Edinburgh Philosophical Journal.

Observations on the Relations of certain Vapours with respect to Heat; by Mr. J. H. Whitehead.

March 13.—On the Anatomical Affinities of the Marsupiata; by Mr. John Hey.

1835.

Nov. 13.—On Alcyonella Stagnorum; by Mr. T. P. Teale.

Dec. 11.—On the Detection of Arsenic; by Mr. William West.

1836.

Jan. 8.—Brief Remarks on the Contracted Second, and certain alleged Imperfections of the Musical Scale, in rejoinder to a former Paper by William Hey, Esq.; by Mr. John Wilkinson.

Nov. 11.—On the Yorkshire Coalfield; by the late Mr. E. S. George, F.L.S.

Dec. 9.—On the Management of the Microscope, and the Verification of Microscopic Objects; by Mr. William Sykes Ward.

LIST OF THE ORIGINAL MEMBERS.

PROPRIETARY MEMBERS.

1 William Aldam,
2 George Banks,
3 Thomas Blayds,
4 R. C. Battye,
5 Richard Bramley,
6 Edward Baines,
7 Robert Arthington,
8 John Cawood,
9 Newman Cash,
10 Alfred Birchall,
11 Edwin Birchall,
12 J. B. Charlesworth,
13 Thomas Chorley,
14 Benjamin Gott,
15 John Gott,
16 William Gott,
17 Henry Greenwood,
18 William Lupton,
19 John Marshall,
20 John Marshall, jun.
21 J. G. Marshall,
22 Thomas Motley,
23 Thomas Makins,
24 John Jowitt,
25 William Hirst,
26 T. B. Pease,
27 George Rawson,
28 Peter Rhodes,
29 J. W. Stansfeld,
30 William Walker,
31 John Wilkinson,
32 George Thackrey,
33 John Walker,
34 T. W. Tottie,
35 Robert Walker,
36 William T. Thompson,
37 John Shepherd.

ORDINARY MEMBERS.

1 John Atkinson, F.L.S.
2 John Atkinson,
3 Joseph Atkinson,
4 Edward Baines, jun.
5 S. J. Birchall,
6 G. W. Bischoff,
7 John Bischoff,
8 Thomas Bischoff,
9 Matthew Bloome,
10 Joseph Bower,
11 William Briggs,
12 E. K. Bullman,
13 John Edward Brooke,
14 J. Burton,
15 John Cadman,

16 Rev. Richard Carpenter,
17 John Carr,
18 Thomas Charlesworth,
19 John P. Clapham,
20 Samuel Clapham,
21 John Cudworth,
22 John Dixon,
23 Joshua Dixon,
24 Joseph Dickinson,
25 John Elam, jun.
26 James Fenton,
27 James Fenton,
28 S. G. Fenton,
29 John Fisher,
30 Joseph Prince Garlick,
31 William Gawtress,
32 E. S. George,
33 Rev. R. W. Hamilton,
34 Samuel Hare,
35 Christopher Heaps,
36 John Hernaman,
37 William Hey,
38 William Hey, jun.
39 George Hirst,
40 Henry Hobson,
41 Adam Hunter, M.D.
42 John Kidson,
43 William Thompson Lee,
44 John Luccock,
45 J. W. Moore,
46 Joseph Muff,
47 Matthew Murray,
48 Joseph Murphy,
49 John Oastler,
50 George Hamer Oates,
51 William Osburn, jun.
52 George Ripley,
53 John A. Payne, M.D.
54 R. E. Payne,
55 I. Procter,
56 John Rothery,
57 Henry Rimington,
58 J. H. Ridsdale,
59 M. T. Sadler,
60 John Sangster,
61 C. H. Schwanfelder,
62 Allen Sharpe,
63 Edwin Smith,
64 Samuel Smith,
65 William Smith,
66 Hamer Stansfeld,
67 Henry Stansfeld,
68 R. V. Swaine,
69 Robert Taylor,
70 J. M. Tennant,
71 C. T. Thackrah,
72 R. W. D. Thorp, M.D.
73 Thomas Trant,
74 T. E. Upton, jun.
75 George Walker,
76 Thomas Walker,
77 William Watson,
78 William West,
79 Jonathan Wilks,
80 James Williamson, M.D.
81 William Wood,
82 Samuel Wormald.

TRANSACTIONS,

&c.

ON THE BED OF THE MISSISSIPPI;*

BY THE LATE JOHN LUCCOCK, ESQ.:

READ ON FRIDAY, NOVEMBER 19th, 1824.

IT may contribute to the clearness and precision of our ideas, if I say, that by the bed of a river we usually mean that channel merely in which its waters flow towards a lower level, and through which they proceed to the ocean. The term *Basin*, as applied

* The following account of the bed of the Mississippi by a valued Member of the Society, now some years deceased, is the result of a personal knowledge of the course of the river, obtained in a lengthened journey through that extensive district in the years 1822 and 23. In order to explain any seeming want of connection which may possibly occur between different parts of the paper, it is right to state that many pages of Mr. Luccock's Manuscript, which did not immediately bear upon the subject, have been omitted. The paper was read before a popular assembly,—not intended for publication,—and the large accessions made within the last twelve years to our geological information, cause observations made so long ago to appear somewhat out of date: it is hoped, however, that in the dearth of notices of North American geology in this country, the present description may not prove unacceptable. It must be borne in mind that the writer was obviously impressed with the truth of the Wernerian System, according to which all the matter of which even primary rocks are formed was originally held in solution by water, and the water so saturated once covered the whole globe. The reader will probably consider that the hypothesis of Mr. Luccock, with respect to the basin of the Mississippi, offers a more satisfactory explanation of some of the phenomena than is afforded by the Wernerian theory of a Universal Ocean.

to a river, is taken in a larger sense, and denotes the whole of that district which pours its waters into the main channel of the stream, however remote the sources of these waters may be from the bed itself, or from each other; and however various in their relative elevations or the courses and declivities of the minor streams.

From these two definitions it is evident that the basin of a river must be surrounded by a contiguous ridge of high-land, except at one point lower than any other, and over which the surplus waters must discharge themselves in their progress to the level of the ocean.

The bed of the river also, will coincide with the lowest line or valley which intersects the basin from whose surrounding high ground or verge, a declivity will every where be formed which tends to the point most depressed in the bottom of the basin itself.

If we contemplate the face of the globe, it every where exhibits the intersection of streams flowing through basins of various depths, figures, and dimensions, each of them communicating with its next and lower neighbour, until the last unites itself with the sea, where the waters escape indeed from their imprisonment between lofty hills and encroaching banks, but by no means there to rest.

If we examine the composition of that land which has long been dry, there are perceived on every side, proofs that water once prevailed over the whole of it. These evidences are traceable, not only on the shores of the deep, but from thence

even to the highest summits of the mountains which have yet been attained.

It is also little less obvious, that in the course of the gradual desiccation of the land or subsidence of the waters that appear every where to have taken place, every hollow on the surface which was capable by its tenacity of retaining water, would be left entirely full of that fluid, and would be kept so by the usual means which at present supply mountain lakes, and that the surplus quantity of fluid discharged from an upper lake to a lower one, would be at least equal to that which has existed at any subsequent period; nor could the momentum of the stream, nor its corrosion of substances which oppose its progress, be less in proportion to the quantity discharged than it is found to be in our own age: and it is certain also, that every such discharge of fluid would not only be made from the upper lake over the lowest part of its verge, but would also make its way to the next lower one by the shortest and quickest passage which nature afforded to it. In the same manner too, the surplus would be discharged from the second lake to a third, thence to a fourth, to a fifth, and so on, through the whole succession or series, until the waters were finally absorbed among those of the ocean.

This will admit of illustration by the present circumstances of the lakes of Geneva and Erie. The surplus of the first is discharged at its southern end through the channel of the Rhone. In the latter, we have a surplus from Lake Superior through those of Huron and Erie, until from the eastern extremity of the latter, it is precipitated over the

barrier of Niagara into Lake Ontario, the river, and gulf of St. Lawrence.

It is scarcely necessary to remark, that every lake, whose supply exceeds the quantity of fluid which it loses by vapours and percolation through its bottom and sides, must be kept full to the natural elevation of its barrier, and that this obstacle must be gradually worn away and rendered lower by the corrosion of the stream which passes over it. Thus the Falls of Niagara appear to have lost at least ninety feet of their elevation; and it would be easy to point out the places where a number of other barriers stood which have already been worn quite away, and whose lakes have, in consequence, been completely drained of their waters. If, indeed, we could ascertain the rate of their corrosion with all the precision which is desirable, many facts in the history of the world, and the states of particular countries, would be greatly illustrated. Unfortunately, at present, our knowledge is not sufficiently advanced for this purpose; but the discoveries of philosophy enable us to say with confidence, that in every case the corrosion must be proportioned to the rapidity of the stream, and the hardness or softness of those materials upon which it acts. When the effect is complete, either the upper lake is wholly drained, or the surface of it reduced to the same level as that of the lower one.

The sides of the worn barrier sometimes remain opposite to each other, like two lofty piles forming the cheeks of a narrow gorge into the desiccated basin.

When the intermediate barriers of a long series of primitive lakes were complete, when they discharged their surplus waters from one to another in the order of their elevation, it is clear that the quantity of their discharge would be increased at every step which they made in their descent, and that the last lake of all would consign to the ocean a quantity composed of the rain and the dews which fell not only upon its own surface, of the springs, and the streams existing not only within the verge of its own basin, but including also the whole quantity which had been successively discharged from every preceding lake. Hence, therefore, if any two barriers were composed of equally solid materials, or nearly so, and of nearly the same height, the corrosion of the lower one must be most rapid, and that obstacle to the stream must be first worn away, and the lower lake would become entirely drained, while the higher one still retained some portion of its water. Hence, also, it occurs, that when the side of the upper lake has been much more solid than that of the lower one, we frequently find the latter completely desiccated, and the former remaining with a cataract in front. Something of this nature is met with on the Rhine, the Clyde, and many other rivers. Hence it is, too, that cataracts are always found on the upper parts of rivers, and *never in* the alluvial soils which compose their estuaries.

So soon as a number of barriers are worn down by the usual and slow process of corrosion, and a succession of lakes, in consequence of being drained, are converted into a long narrow and winding valley, they

become the basin of a river through whose channel is still discharged the same quantity of water as once constituted the surplus of the whole line of lakes. The stream also, still continues to corrode its bottom, to fret away obstacles, and to hurry their ruins before it.

It is not difficult, wherever the ruins of a barrier are very conspicuous, to ascertain the high-land on each side of the river between which it lays; to trace to their greatest elevation upon each cheek the effects of corrosion; and then to follow the horizontal line along the neighbouring hills, until they again converge and point out the barrier of the next superior lake. The observer will then conclude that all beneath, and within the range of that line, must have been filled with water and formed the bed of a lake, whose figure, extent, and depth, he has rendered evident. This is somewhat allied to the method which I shall now adopt, while conducting you round the basin of the Mississippi.

This basin is bounded on the West, by the chain of the Rocky Mountains; on the East, by the Alleghanies: and in the course of the gradual subsidence of the waters from the North American Continent, we may suppose a period to have existed, when the waters of the Atlantic spread themselves in one unbroken sea over all the present United States, except a small strip of land in the Western territory. The shore of the ocean would then extend from the Catskill Mountains, round by the North of Lakes Erie, Huron, and Superior, and thence, about south-west, to the sources of the Colorado, forming a bay of

much larger dimensions, but answerable in its form and position to the Gulf of Mexico at present, and produced originally by the constant operation of similar causes.

The lakes of Canada would begin to assume their shape and respective figures, even at a time, when through a broad space the tide would flow uninterruptedly from the Gulf of St. Lawrence to that of Mexico. After a considerable further subsidence, the verge of the great Mississippi Lake would be complete, except in the North, where a narrow passage united it still with Lake Michigan, and a broad one on the South, by which its waters were discharged into the Gulf. The curious on such subjects will be surprised to find, that even then, when the centre of the American Continent was full of water, its surface stood only about sixty-six feet above that of Lake Erie now; and so slow is nature in the process of corrosion when waters are shallow and unconfined in their breadth, that, even at this day, in the season of floods, there is a free navigation for boats from Lake Michigan to the Mississippi, and from the river to the lake.

In tracing the two lateral chains down to the level of seven hundred and twenty feet, we find them approach each other, one through the State of Alibama, the other, through that of Louisiana, until they almost meet at the gorge of the river. It is, perhaps, now too late to ascertain, whether ever this southern barrier was complete, and whether it was equally high with the northern one; yet the circumstance that these ridges approach each other through a

distance of more than one thousand miles, that both of them gradually decline, and through the latter half uniformly, and that the distance between their spurs is no more than a proportionate space with streams of inferior magnitude, it seems reasonable to conclude, that the southern barrier may have been once like the northern, complete and effectual.

In the Summer of 1822, and again in November of the same year, I had an opportunity of examining this extraordinary gorge of one of the largest, the most regular, and most powerful rivers on the face of the earth; and confess that a conviction of a barrier once having existed at this spot, and borne back the Mississippi was impressed upon my mind, much in the same way, and in the same degree, as it would have been had I found the ends of a broken bridge on each side of the stream, that at some former period a succession of arches had stretched across the river, and afforded an easy, a dry, and a secure passage over the water. If further arguments to this effect be wanting, we may add to geological deductions from the tendency of the mountains and the similarity of their structure, the circumstances that each cheek of the gorge is composed of similar materials and in the same order, that both exhibit water-worn traces to the same degree of elevation, and that men of science, who have examined the spot, have been convinced of the fact. Both Dunbar and Darby, each of them well known to the world, resided near this celebrated pass, and have examined it with care and published their opinions. To one of them also we are indebted for

our acquaintance with Red River, and to the other for what we know of the Ouachitta.

If, then, this barrier did actually exist across the Mississippi, it must have extended from Loftus Heights on one side of the river to Sicily Island on the other, thence to the Prairies of Opelousas, across the deserted bed of the Teche, and to the high-lands of Louisiana, near the heads of the Sabine River, where it joins the great spur of the Saba or Caous Mountains. Here it is, while passing this range, that we first behold the Mississippi, in all its magnificence, rolling through a fine natural canal, full seven miles long, one thousand two hundred yards broad in every part, and perfectly straight. Its eastern bank, for many miles, is from two to three hundred feet above the level of the stream, composed of slightly adhesive sand, in yellow, brown, and white masses, with a texture generally so hard as to support a face almost perpendicular, but not sufficiently indurated to be denominated or made use of as sand-stone. This bed is about two hundred feet thick on the immediate border of the river, and rises more than another hundred further inland. It extends through the whole country northward, almost to the Tennessee, but becomes thinner as it proceeds, for the under stratum rises in the same direction, and consists of gravel slightly conglomorated and every where pervious to water. At Loftus Heights the upper surface of this stratum is just even with the water's edge, where the river is low, and at this period, the channel is seventy feet deep; but whether it has cut entirely through the whole thickness of the bed, is not yet known. The

lowest known stratum of the country consists of soft lime-stone, generally in thin horizontal strata, which seem to extend almost from the eastern shore to the Canadian Mississippi, and from Lake Erie, under the whole country southward of the United States, Texas, and that part of Mexico which lies near Vera Cruz. The Mississippi proper, and the Ohio, with most of their tributary streams, through their whole course, have cut their way completely through the superincumbent strata down to this solid bed, but below their junction with the Missouri, the whole country bordering on the course of that river is alluvial in the strictest sense of the term.

Supposing then, that the barrier for which I contend, once existed across the Mississippi at Loftus, we have strong reason to believe, that it was composed chiefly of sand, with some mixture of clay; that it did not possess sufficient tenacity to render it wholly impermeable by water, but was hard and heavy enough to render the percolation slow; and, that in the time of floods at least, the waters rose sufficiently high to be discharged over its ridge, and so to wear it down.

The effects which such a barrier would produce upon the waters of the Mississippi, in causing them to accumulate behind it and form a lake, may be easily conceived; and if its ridge was ever seven hundred and twenty feet above the present level of the sea, the waters of that lake would extend over the whole country between the Lakes of Canada and the Gulf of Mexico. On the eastern bank of the river, we can now distinctly trace the effects of water to three hun-

dred feet above the level of the present stream at Loftus. There, also, it has yet to flow ere it reach the tide-way, a distance of two hundred and fifty-nine miles. Now, allowing for the fall of the current only two inches per mile, we have a difference of forty-three feet between the level of the river at this point and the gulf. The gulf is supposed to be one hundred feet higher than the surface of the sea off New York; and these items form a total of four hundred and forty-three feet, which may be now ascertained as the lowest possible level of this barrier when complete.

That this obstacle should have been gradually worn away, will create no surprise, when we consider the looseness of its texture and the magnitude of that stream whose surplus passed over it; which, as we have stated before, could not be less than the whole discharge of the river at present, a quantity which, when calculated from the most moderate data, may well astonish us, for it comes out somewhat more than one billion six hundred and thirty millions of cubic feet of water per hour, and its floods, during the season, nearly double the quantity.

When this barrier was as high above the sea as the corresponding one on the north side of the lake, the sheet of water formed by its discharge, must have been about one hundred miles broad—when it was worn down to three hundred and sixty feet, this communication with the gulf was reduced to about thirty-three miles in breadth—when the elevation was reduced to one hundred feet above the present level of the stream, it would form three communications with the gulf, one of them ten miles broad, the two others

narrow,—and when reduced to its present state, we find the stream has been diminished to one thousand two hundred yards in breadth.

At the same time, as the height of the barrier was reduced, in a corresponding ratio would the extent of the lake which it formed be diminished. Long previous, however, would a ridge of high-land have appeared across its centre from East to West, extending from the Alleghany Mountains south of the Tennessee River, whose course it directs, then crosses the Ohio and Mississippi near their junction, where the ruins of it are still very conspicuous, finally uniting with the western ridge at Cape Girardeau, and bearing up the Kansas, a large tributary of the Missouri; thus dividing the great Lake of the Mississippi into two parts, an upper and a lower lake.

When ascending the Ohio, we pass the gorge of this central ridge near to Golconda, where the surface of the stream is probably one hundred and seventy-five feet above the Gulf of Mexico, and the height of the cheek about two hundred feet; which, added to the elevation of the gulf itself, as stated before, yields four hundred and seventy-five feet as the lowest possible height of this barrier.

This barrier was evidently composed of more solid materials than the more southerly one; for here, the solid limestone, the cera of the whole country, has risen to the surface and forms the hills. It is, however, so full of exuviæ, as clearly to evince its former soft condition at the bottom of the lake or of the ocean.

It is probable that the first of these barriers was worn down, as already stated, by corrosion, that this

second gave way by sudden disruptures, or by means of such subterranean tunnels as I attempted to describe in a former paper, for many such tunnels abound in this neighbourhood. Hence, then, it seems, that the waters of the upper lake, which was never a very deep one, were drained off in masses, as a new breach was made, a new tunnel completed, or an old one enlarged, and thus would necessarily produce very material effects upon the condition and circumstances of the lower lake. The effects of such an accident are very remarkable higher up the Ohio at Augusta, where the population of a small district appear to have been drowned and buried while asleep, by the water and mud which the sudden rupture of an upper lake permitted to descend upon them.

The lowest point of this central barrier, and, of course, the last, whereby the upper and lower lake freely communicated with each other, lies exactly in the line of a great valley, which proceeds from Lake Michigan to the Gulf of Mexico, one of the most remarkable features in North American geography. This vast and singular valley extends from Lake Michigan down the course of the Illinois, that portion of the Mississippi which is most improperly named, and along the whole line of Louisianan swamps to the mouth of Acapulco, where its waters unite with those of the gulf. This remarkable tract of low meadow land, which is perfectly direct and nearly smooth, thirteen degrees in length, gradually expands from the width of a small river at one extremity, to a breadth of fifty miles at the other, and has a declivity of no more than six hundred and twenty feet from the

source of the Fox River to the Bogs of Atacapas. In the general desiccation of the earth, and the consequent formation of countries, this, it is evident, would be the last line of communication between the Gulfs of St. Lawrence and Mexico through the lakes of Canada, and would, therefore, give the form and impress to the whole interior of the North American continent.

I cannot persuade myself to take leave of the subject without suggesting that it would be interesting to connect with it an examination of that great basin in which the Canadian lakes are found. Their only point of discharge is by the river St. Lawrence; their last remaining obstacle at the Falls of Niagara; which, indeed, is also rapidly wearing away. The height to which it once existed, is still clearly visible; the depths of the lakes which it formed, most accurately ascertained; and the measure of its corrosion in a definite series of years, almost known: further investigation would furnish, what appears to me at least, the most valuable results.

"ON THE VARIETIES OF WATER,"

BY WILLIAM WEST:

READ 6th NOVEMBER, 1829.

UNDER this title I propose to treat of such varieties of Water as are found native in abundance, and are applied to domestic purposes, as well as those which, from their dissolving in their passage through mineral strata such substances as impart powerful medicinal qualities, are termed mineral springs. I shall add some waters from other remarkable sources.

The water of different districts varies; trial after trial of water from the gritstone moors will show it to be soft and nearly pure, while that which springs through limestone is hard, brisk, and yields a large residuum on evaporation. The water of the same district varies; in families where convenience and comfort are studied, it is not uncommon to find one sort reserved for drinking and another for washing, while a third, more abundant, or more accessible than these, is employed for other purposes. For water of absolute purity we must resort to the combination of its gaseous elements, or to repeated distillation in glass vessels, but the properties of Water almost pure may be examined and compared with those of varieties of ordinary occurrence, from water once distilled through metal, or from rain-water collected

at the end of a shower, in a situation remote from houses.

When in this state of purity, it is chemically distinguished by negative characters, not undergoing any change in its appearance on the addition of the tests by which we ascertain the presence of foreign substances. The varieties of water most commonly met with are soft and nearly pure, or contain Chloride of Sodium, (common salt,) or Sulphate of Soda, or Carbonate, Sulphate or Muriate of Lime, with or without Carbonate, Sulphate or Muriate of Magnesia. Of these substances several are often found present in the same specimen; in some one substance predominates so as to give a distinct character; in others we find properties derived from various impregnations, no one of which appears to predominate over the rest. Of these last we may form a judgment very useful for practical purposes, by weighing the residuum left after evaporation to dryness, without resorting to the tedious and troublesome operations needful for separating each of its constituents. Another variety is very soft, from the presence of Carbonate of Soda; here the proportion of solid matter left on evaporation furnishes no clue to its qualities, because it may be more or less mixed with earthy salts, whose effects counteract those of the Alkaline Carbonate. Another is formed by Chalybeate Waters; these are unpleasant to the taste, and objectionable in some other respects, to a degree much beyond what would be the case from a corresponding weight of Alkaline or earthy salts.

Vegetable and animal mixtures introduce great

difference among waters bearing close resemblance in the nature and quantity of the salts accompanying them. Lastly, some sources from which water is taken bring with them Carbonate of Lime, Silex, or Alumina (Chalk, Sand, or Clay,) as well as the remains of vegetables, not dissolved, but suspended in a state of minute division.

WATER CONTAINING SALTS OF SODA.

The *Salts of Soda* have far less effect than those of Lime or Magnesia, in hardening water, that is, in lessening its solvent power, and detergent properties.

Sulphate of Soda is contained in many waters, seldom alone, but often as one of the mixed salts in hard land springs.

We may infer the predominance of Sulphate of Soda, without an exact analysis, when we find a great effect produced on the tests for Sulphuric Acid, of which Muriate of Barytes is the best, with little action on those for Lime and Magnesia. Sulphate of Iron is occasionally met with in considerable quantity, but the taste of such water, and the brown colour which it acquires on standing, sufficiently distinguish that variety. I am not disposed to attribute any marked qualities to Sulphate of Soda, when occurring in common proportions. The purgative effect of some mineral waters, as those of Cheltenham, is owing to this salt. In some instances, as at Tuxford in Nottinghamshire, it occurs in the ordinary domestic waters, in a proportion sufficient to produce decided medicinal effects on those

unaccustomed to its use, though the inhabitants find no such inconvenience.

Muriate of Soda, or Common Salt, now denominated by chemists Chloride of Sodium, may be distinguished by furnishing a copious precipitate with Nitrate of Silver, which precipitate is soluble in Ammonia, but insoluble in Acetic Acid. If this be the only Chloride present, no action is produced on the tests for Lime and Magnesia.

Of waters deriving their distinguishing properties from Common Salt, the most abundant and most generally known is that of the Sea. Sea Water has repeatedly been analyzed with very great care. Dr. Murray's analysis, which appears very correct, gives as the saline contents of an Imperial Gallon,

Common Salt.....	1540 Gr. or about	3½ Oz. Av.
Sulphate of Soda	232	½
Chloride of Magnesium	294	¾
Chloride of Calcium ...	55	
Total	2121 Grains.	

When Common Salt exists in such quantity as to be plainly perceptible to the taste, the water is said to be "brackish," and has some very disagreeable and injurious qualities. Such water is common on the sea-coast, and in some other situations. The sulphureous water of Harrogate, contains about nine hundred grains of Muriate of Soda in the Imperial Gallon—one part in eighty.

But it is also found in many springs, in smaller quantity, so as not to be distinguishable by the taste. The river Thames yields 1·4 gr. in the gallon, one

part in fifty thousand. Pump waters, very agreeable, but of no distinguishing flavour, contain from ten to fifteen grains in the gallon, or at least the Chlorine and the Sodium constituting that quantity of Common Salt.

Carbonate of Soda is found in some parts of the globe, as a constituent of water, to a very great extent. Lakes exist in Africa, the Soda obtained from which forms, under the name of Trona, an important article of commerce.

The expression "though thou wash thee with nitre and take thee much soap," will be in the recollection of many: it refers to Trona, or Natron. Nitrum has been used by our translators for Natron. Nitre, Nitrate of Potash, has no detersive properties.

The excellent water so advantageously obtained by boring in the neighbourhood of London, contains a sensible quantity of Carbonate of Soda, but waters dependent on this salt for their medicinal effects, have not obtained such celebrity in this country as to have their composition or mode of analysis inserted among the usual notices respecting mineral waters. In this part of the country they are so abundant and so highly charged with the Soda as to claim the particular attention of the analytical chemist. We have in this town the Holbeck Water, so useful for some domestic purposes, and so valuable for the manufactories.

A minute account and analysis of this water was published by E. S. George, Curator of this Society, in the Annals of Philosophy. The results of my

experiments were the same. The quantities, calculated by the Imperial Gallon, are

Carbonate of Soda...	38·4	Grains, equivalent to 102·4 Crystallized Subcarbonate.
Grains of the		
Chloride of Sodium	4·2	
Chloride of Calcium	·6	
	43·2	

I have had similar water brought to me from Park-Place, on the North side of the river Aire; I have heard of it at Bradford, but have not met with any from that locality.

The water of Slaithwaite, near Huddersfield, strongly resembles that of Holbeck. At Stanley, near Wakefield, it is a stronger as well as purer solution of alkali. Similar water is found in different parts of the North Riding of Yorkshire. Waters containing Carbonate of Soda may be recognised by their affording, with various earthy and metallic salts, as Chloride of Calcium and Acetate of Lead, precipitates soluble with effervescence, in diluted Nitric or Acetic Acid. Holbeck water has been long deservedly celebrated for its softness; as shown by its cleansing properties and by the strength of the infusions prepared with it. Wonderful accounts are given of the economy attendant on its use, both with soap and for tea. So far as the first of these is concerned, there is, I think, no reason to doubt the accuracy of these statements. Water containing a notable proportion of Carbonate of Soda must of itself possess strong detergent powers, and by its freedom from earthy salts it would leave undiminished the full action of whatever quantity of soap

might be employed. In what degree it deserves the encomiums it has obtained for its virtues on the other score is more open to question. Some, indeed, who have noticed the deepening of colour which takes place when Soda is added to an infusion of Chinese Tea already strained from the leaves, consider this as the sole effect of using a natural or artificial solution of Soda or other alkali in its preparation, and represent the whole of the supposed increase of strength as a deception of the eye.

I have taken much pains with a set of experiments to settle this point among others; viz. "On the comparative solvent powers of water holding in solution various salts in different proportions." I have come to the conclusion, that the earthy salts exert a great influence in *preventing* the solvent action of water on some vegetable substances; the proportion dissolved by pure or soft water being in some cases considerably greater than that by hard water. Portions of tea of the same weight, viz. thirty-six grains, after drying, with equal quantities of boiling water of different kinds, standing in similar vessels for the same time, yielded, the hard water, after deducting the weight of the earthy matter, about four grains of extract, that is, the infusion left, besides the earths, four grains, on evaporation to dryness; the leaves again dried weighed thirty-two grains: the extract from the soft or distilled water was pretty exactly eight grains, the leaves, after drying, twenty-eight grains. Thus the soft water had extracted from the tea just twice as much as the hard. I made numerous experiments of the same description, but found it difficult from

circumstances connected with the absorbent nature of the leaves, to obtain exactly the same quantities of extract and of spent leaves, in repetitions of the same experiment, and cannot therefore depend on this mode of comparing waters differing little from each other. And the effect of pure water is certainly very near to that of any natural water containing Carbonate of Soda. I think, however, that the Soda does a little increase the quantity taken up, and that it is probable the celebrity of this water for such purposes depends on three circumstances,—the real increase of solvent power, the darker colour, giving the appearance of greater strength, and the sensibility of the palate being increased by the Soda. There is another use for which this kind of water excels; it is the supply of Steam Engine Boilers; so far from any earthy crust to require chipping out, there is, when the water of Soda is unmixed, no disposition to produce Fur. The account given me by the engineer at Slaithwaite was, that it preserves the inside of the Boiler "bright like silver." Whether this be literally correct or not, the advantage must be very great of the heat being conveyed immediately to the water, without having to pass through any difficultly conducting substance. Since, however, with all this superiority, Holbeck, or natural Soda Water, is found to exercise considerable medicinal influence in cases where its effects are by no means required, I doubt its being perfectly suited for the main supply of a great town, and should prefer a pure unimpregnated spring for that purpose, as well as for the use of manufacturers, where an Alkali would act upon the colour of the goods.

SALTS OF LIME.

The *Salts of Lime* all render water hard, that is, they impair its power of dissolving animal or vegetable matter, and consequently its cleansing power when used alone, and they decompose soap.

The acid of the earthy salt combines with the alkali of the soap; the lime combining with the oil forms an earthy soap, insoluble in water, at the same time that it is pasty and adhesive. It is common to add Pearlash or Soda to such water to render it soft, an object which may thus in some degree be effected.

When the process is most completely performed, by boiling the Carbonated Alkali with the water, and allowing it afterwards to settle before using, there is a complete decomposition of the earthy salts; the Soda or Potash combines with the acid which held in solution the Lime or Magnesia, and the Carbonic Acid forms an insoluble carbonate of the earth. At the same time the excess of alkali above that required to decompose the Salt of Lime has a direct tendency to increase the solvent power of the water. In proportion to the completeness of this decomposition will be the softening produced; but in the mode in which it is commonly applied, much must be set down to the detersive properties of the alkali itself, and it is at best but an imperfect, as well as on a large scale, a costly substitute for a supply of water free from earthy impregnation. The earthy soap formed by Lime is white, granular, and heavy; when the proportion of Lime is considerable, as in hard pump water, the

soap is entirely decomposed, and the water left transparent.

Sulphate of Lime furnishes no such instances of abundant quantity as some other salts. This arises from that salt being but sparingly soluble in water, about one part in five hundred. But if it fall short in proportionate weight, in objectionable properties it goes beyond most of the other substances commonly met with.

Sulphate of Lime, being held in waters by its own solubility, cannot be wholly separated by mere boiling: on applying heat to its solution one of two effects takes place; if the solution is weak and evaporation is slow, the solution is left more concentrated; if it be boiled briskly, the solution may remain of the same strength, though not saturated, while a portion of the Sulphate separates in a solid form. The manner in which this proceeds is curious; the property is common in a greater or less degree to all substances difficultly soluble, though Lime itself is the most striking instance. When a bubble of steam arises, the salt which was dissolved in that portion now vaporized, separates in the solid state, and as such bodies require not only a large portion of water, but a long time, to effect solution, before this is again dissolved many other particles are separated; and thus the quantity deposited goes on increasing, the strength of the solution itself remaining all the time nearly the same, though any difference which may take place is, of course, in the way of increase.

Thus in the production of "Fur," in the vessels

in which it is boiled, the Sulphate of Lime acts about as speedily as the Carbonate, and probably more injuriously. In many operations, therefore, it becomes a very serious evil. I was assured at Manchester that it was necessary frequently to empty the engine boilers and chip out the crust formed, in some cases as often as once in six weeks; the labour of effecting this, and the hindrance to work and loss of fuel consequent on letting out the fire, are not the only disadvantages attendant upon the circumstance. The boilers must be more quickly destroyed, from the great heat of the outside being very slowly conducted through the earthy crust. In fact they told me that for a short time before the usual periods for cleaning, it was difficult to get the steam up, whatever fire was employed. Nor is the employment of the Sabbath for this purpose to be left out of the question. The adhesion of the earthy matter to the Iron is lessened, and the interval between the cleanings consequently prolonged, by the use of potatoes, the pulp of which enveloping the crystals, lessens their tendency to cohere, and preserves them for a time suspended in the water of the boiler.

Muriate of Lime, or more properly Chloride of Calcium, is a very common attendant on Muriate of Soda. In Sea Water it is in the proportion of one thirtieth part of the Soda Salt. In Harrogate Water it is one tenth, or one twelfth, of the Chloride of Sodium. In Oddy's Saline Chalybeate, or Harrogate Cheltenham, it is one fifteenth; in Leamington Sulphur Water a half, &c. &c. &c. I may remark, that Rock Salt is generally mixed with Muriates of Lime

and Magnesia, though in far less proportion than in the water of the sea.

At other times Chloride of Calcium accompanies Sulphate of Soda, and it sometimes occurs alone, but I think not frequently, and that the solution is generally very weak.

The waters of Malvern and Ilkley, which have their respective medical pretensions, are said to yield nothing on analysis besides very small proportions of Chloride of Calcium.

There is no reason to suppose that the Muriate of Lime exists already formed in the bowels of the earth; it is most likely a product of decomposition; yet we can hardly account for its formation from the Carbonate or Sulphate, the principal native Salts of Lime, without the presence, in solution, at the same time, of equivalent proportions of some soluble Salt of Soda, or of Alumina.

Carbonate of Lime.—Waters containing Carbonate of Lime in large quantity form petrifying springs. Carbonate of Lime does not dissolve in pure water; but dissolves in considerable proportion when an excess of Carbonic Acid is present. Carbonic Acid is capable of rendering its own weight of Carbonate of Lime soluble in the water in which it is itself dissolved. The waters of Baden, Toplitz, Seltzer, Pouges, Carlsbad, &c., on the Continent, and those of Buxton, Bristol, and others, in this country, contain a considerable quantity of Carbonate of Lime dissolved in this way. Their medicinal qualities depend, however, on other constituents.

That water impregnated with Carbonic Acid Gas

should, in flowing over or through lime-stone, readily dissolve a portion is perfectly natural; but how the Carbonic Acid is obtained is less obvious.

Such water, on boiling, suffers the excess of Carbonic Acid to escape in the form of Gas, when the Carbonate of Lime separates in minute crystals.

It is also separated partially by standing; the Gas slowly escapes, and allows the Carbonate to subside.

Such water may be rendered much less hard by abstracting the Carbonic Acid by means of Potash or Soda, or by boiling alone, provided the water be suffered afterwards to stand to deposit the Carbonate of Lime. The Carbonate thus separated is one source of the fur which so often lines boilers and tea-kettles.

I have ascertained that Carbonate of Lime, merely diffused through water, interferes considerably with its power of dissolving soap.

SALTS OF MAGNESIA.

The *Salts of Magnesia* are generally accompanied by Soda, and always by Lime. The proportions vary greatly; the Magnesia in Sea Water is five times the Lime; in Cheltenham Sulphur Water four times, in the Water of Spa three times, Cheltenham Pure Saline two and half times, Pyrmont twice. In Carlsbad, Harrogate, and Leamington Waters, the Lime predominates. Thames Water contains only a slight trace of Magnesia. The hard Pump Water of this place, and of Sheffield, and similar waters from other parts of this County, contains a quantity rather less

than that of the corresponding Salt of Lime. Magnesian waters form, with soap, a hard very white substance in shining flakes, a soap of the earth, considerably lighter than water, insoluble in that fluid, and separating at once from it. The most striking instance of a water containing Muriate of Magnesia, and one of the most remarkable waters in the world, is that of the Dead Sea.

An amusing account of a visit to this Lake is given by a late traveller, Dr. Madden, who relates various circumstances dependent on the strong impregnation and consequent density of the water, but he seems to have added nothing of a scientific character to our previous knowledge of this extraordinary Lake. Dr. Marcet analyzed some of this water, and found it to contain about one fourth of its weight of salt, viz. in one hundred parts of water about ten and a quarter Chloride of Magnesium, ten and a quarter Chloride of Sodium, four Chloride of Calcium, a very small quantity of Sulphate of Lime, and seventy-five parts of water.

Sulphate of Magnesia derives its name of Epsom Salt from its predominance in the medicinal springs of Epsom. It is less common than the Chloride.

Carbonate of Magnesia is less frequently met with than the Muriate, but in this neighbourhood Magnesia in some state of combination generally accompanies Lime.

IRON.

Iron exists in water in various states, and in very different proportions. In those cases where it does

not prevent the use of the water for general purposes, it is generally in the state of Carbonate, dissolved like Carbonate of Lime, by excess of Carbonic Acid, and separable from it in the same manner. It is thus found in hard and soft waters, according to whether it accompanies the earths, or is the sole or principal constituent. The quantity, in Spa and Pyrmont Waters, is about four grains per gallon, in Tunbridge and in Bath Water, half that quantity, in Oddy's Harrogate Chalybeate, about three grains. I have found from two to five grains per gallon in several waters in different situations.

Frequently, however, the proportion is much smaller than this, down to less than a grain, yet sufficient to impart a marked character to the water.

In the first place, Iron produces its medicinal effects, in much smaller doses than alkaline or earthy salts; throbbing temples, flushed countenance, and plethoric head-ache, may, in some constitutions, attend the continued taking of a quantity of Iron so minute that the same weight of the salts would be wholly inoperative. In washing also, both white linen and delicate colours are liable to be stained by the continued use of water containing Iron in very small quantity. Upon its effect in brewing there is some difference of opinion; such water is often objected to for that purpose: it may perhaps interfere with proper fermentation, and if the Iron remain dissolved it may, in public breweries, bring the beer under the notice of the Excise, on suspicion of Sulphate of Iron having been purposely added. Carbonate of Iron is more speedily separated on heating, and much more

completely on standing, than the earthy Carbonates. A double operation takes place, for while Carbonic Acid, the solvent, is given off, Oxygen is still more rapidly absorbed, by which the Iron, colourless while in solution, is soon changed into the brown insoluble Carbonate. Hence, wherever such water flows, it leaves an ochreous deposit.

The production of a black colour, with vegetable astringents, renders Chalybeate Waters unpleasant for mixture with spirits or for tea.

The Sulphate and Chloride of Iron are still more marked in their properties, and more objectionable than the Carbonate.

The use of Iron Pipes for the conveyance of water has very much increased of late years, and they possess several advantages; they are stronger than wood, so as to bear the pressure of a "head" of water, as well as much more durable, and they are cheaper than lead, at the same time that their use is free from the possibility of deleterious impregnation. Occasionally, however, considerable inconvenience arises, especially while the pipes are new, from the water carrying with it Oxide of Iron.

This sometimes continues for a considerable period. Lime added to the water in the reservoir, which is then allowed to flow freely through the pipes, is said to coat them with Carbonate of Lime so as to prevent further action upon the Iron; and the hardness and taste of Lime go off in a few days.

Among the substances found in water, besides those which I have thus described, are

Silica,	Fluoric Acid,	Manganese,	Iodine,
Alumina,	Phosphoric Acid,	Potash,	Bromine.
Strontia,	Boracic Acid,		
Baryta,	Nitric Acid,		
Lithia,			

But they are either small in quantity, and insignificant in their effects; or they are found only in a few situations, so as not to require further notice on the present occasion.

GASES.

The *Gases* usually found in such waters as are commonly employed for other than medicinal purposes, are Carbonic Acid Gas, Azote or Nitrogen, and Oxygen.

Accompanying Carbonate of Soda there are commonly small portions of Sulphuretted Hydrogen and of Carburetted Hydrogen; but these soon escape on exposure to the Atmosphere, leaving the water free from its original unpleasant smell. Oxygen Gas is less frequent and less abundant in Water than might be supposed. In many cases I have proved its absence by introducing into the water substances which readily absorb Oxygen, by exposing to such substances the Gas separated by boiling, and by exploding a mixture of the Gas with a known quantity of Oxygen, and more than its equivalent of Hydrogen. This absence of Oxygen is easily accounted for where substances exist which would at once combine with it, as Oxide of Iron, or Sulphuretted Alkalies; but I have had the same results in cases where it might have existed without interfering with the constituents of the water.

From its absence under these circumstances, as well as upon other grounds, we may infer that the Gases disengaged from Spring Water are not absorbed from the atmosphere, but are formed and taken up by the water while in the earth. Standing water and streams, however, undoubtedly absorb air. Dr. Ure states that he obtained from such waters about one thirty-fifth of their bulk of Gases, namely from one twentieth to one tenth Carbonic Acid, and the remainder common air. He does not, however, say whether he tried any experiments to ascertain this last point, or only assumed it to be so. I have invariably found less Oxygen in proportion to the Nitrogen than in air, and from the principles which determine the absorption of gases by water it should be so. I have also always obtained a greater portion of Carbonic Acid, as well as a greater volume of the mixed gases than Dr. Ure.

From hard brisk pump water I obtained by boiling, quantities which, in round numbers, and for the Imperial Gallon, varied but little in repeated trials from sixteen cubic inches of Carbonic Acid, and the same quantity of a mixture of Azote, with a small quantity of Oxygen.

The water of the Aire, taken from the cut which supplies the Waterworks, gave 2¾ Carbonic Acid, and 11¾ Azote and Oxygen; the total quantity of Gases being less than half that from pump water. From that of a large fish-pond I obtained more Gas than from the river, but less Carbonic Acid, viz. 2¼ cubic inches of Carbonic Acid, 14 inches Azote, and 2 Oxygen.

Sulphuretted Hydrogen gives a powerful medicinal character to the water in which it abounds: its offensive smell, and its property of reducing metallic oxides, and thus confounding all colours into which lead enters in a deep slate grey, would render it a very disagreeable attendant were it both abundant and common.

In most cases, however, as at Holbeck, Stanley, &c., though it is sufficient to give a distinctive smell when the water is fresh drawn, it is soon decomposed or dissipated, by standing.

It is only within a very few years that Carburetted Hydrogen has been recognized in water. Its presence was first noticed, I believe, by Drs. Scudamore and Garden, in Harrogate Sulphur Water. It is found accompanying Sulphuretted Hydrogen in every water analyzed by me in which that gas occurs, and is disengaged from many springs in much greater quantity than the water can absorb, forming large bubbles. These, from their inflammability, and from the smell imparted by the mixture of Sulphuretted Hydrogen, are often mistaken for that gas.

The changes which take place as to the Gases, when brisk pump water is exposed in open vessels, are rather curious. I found that water yielding twenty-six cubic inches, viz. ten Carbonic Acid, and sixteen Azote, &c., when fresh drawn, gave, after standing five hours, twenty-five inches, the diminution was in the Azote; the Carbonic Acid remaining the same. At the end of nine hours the total gases twenty-two inches; one-fourth of the Azote had escaped, but very little, not two per cent. of the

Carbonic Acid. After three days, however, the case was different, no further escape of Azote had taken place, the water yielded about fifteen inches per gallon, and of this only from one and a half to two consisted of Carbonic Acid. The quantity of this gas was smaller than in river or pond water. If these experiments are tolerably correct, they would show that, on exposure to the atmosphere, the Azote and Oxygen contained in water very soon begin to separate from it; that after a time the Carbonic Acid partially escapes, the other gases remaining; and that this continues until very little Carbonic Acid is left. The power of water to retain gases in solution, depends, the temperature and pressure remaining the same, on the affinity of water for the gas, and upon the proportion of that gas in the superincumbent atmosphere. Those having a great affinity for water, fly off in some degree when the gases above the water are wholly different, and those least readily absorbed, are retained under an atmosphere of the same gas. Now these two are antagonist principles in the case before us; Azote having little affinity for water, but constituting four-fifths of the surrounding common air, Carbonic Acid being much more abundantly absorbed, but having no atmosphere of its own description to press on the water containing it. No calculation could enable us, I think, to ascertain beforehand the order and the degree in which these effects would take place; that is, to predict the result of these experiments.

ANIMAL AND VEGETABLE MIXTURES.

On the subject of animal and vegetable admix-

tures much might be said, were we to enumerate all the possible varieties, but as their nature is so similar, the whole need not detain us long.

Such animal substances as are met with in water, either diffused or dissolved, will commonly be of the most disgusting kind, and in a state of putrefaction. Vegetable matter is not altogether so objectionable; it is introduced from less offensive sources, and is generally speaking less prone to decomposition.

Some deep coloured peaty water which I have kept three months in a bottle partly full, has become somewhat paler, but has at no time had any smell. Undoubtedly where pure water can be obtained with ease, all mixture of organic bodies should be avoided. The evidence before the Royal Commission, and the Committee of the House of Commons, show the prevalence of such mixtures in "the Silvery Thames" to a frightful extent. Of the degree in which they exist in the water as delivered to the houses, we have some particulars in the evidence. The deposit of mud in the cisterns amounts, it appears from these, to from one to two inches in the year.

Dr. Bostock was employed by the Commissioners to make analyses of sixty specimens of Thames water, taken from various places and under different circumstances as to time of tide, &c. After separating all he could by mere subsidence, and in many of the specimens this quantity was very large, he filtered the waters and proceeded to their analysis. In the best waters, as to cleanliness, and in the worst, he found a

striking similarity as to the saline contents, the former yielding in the Imperial Gallon,

Carbonate of Lime.....	12·24 Grains, the latter	12·4
Sulphate of Lime	1·2	·96
Muriate of Soda and Muriate of Magnesia	1·6	1·8

But the dissolved organic matter in the best was a little more than half a grain in a gallon; in the worst it was upwards of sixteen grains, forming indeed more than half of the total residuum on evaporation. Where the sources from whence this matter is derived are so offensive as in London, the idea cannot be pleasant of receiving into the stomach, after any process water, which has once been thus contaminated; and we might be tempted to reply to any proposal for its purification, as an eminent surgeon (Abernethy) is said to have done, "There is such a thing as common sense." But we know that at that time multitudes were pouring down their throats copiously and in a variety of shapes that very water unpurified. And the reflection that something similar takes place in many other large towns, should dispose us to listen patiently to the suggestion of any remedy.

Now besides the superiority of filtering over mere subsidence for the mechanical separation of impurities, I think enough attention has not been paid to the power of Alumina to separate both animal and vegetable matter, however perfectly dissolved.

I evaporated deep-coloured peaty water, previously filtered, and very bright, and obtained at the rate of 1·6 grains from one pint. On calcination these 1·6 grains were reduced to ·6. About ·8 grains of the

quantity thus dissipated was vegetable matter; ·2 or upwards was Carbonic Acid, from Carbonate of Lime.

I then separated the colouring matter by well washed Alumina; the water was left perfectly limpid; on evaporation it left one grain, which on calcination became ·6 as before; allowing for the Carbonate of Lime decomposed by the heat, not less than four-fifths of the vegetable matter had separated in combination with Alumina. I exposed a weak solution of Gelatine to similar treatment, with correspondent results; the greater part was separated in the same manner; the water evaporated left little but the salts contained in the jelly. I ascertained that common clay produced, by allowing longer time, the same changes in appearance, and that the weight of the dissolved matter was less than before; but I could not easily free the clay so entirely from salts as to bring the proportion separated to the same degree of certainty by weighing. I once saw an amusing proof of the quantity of impurity of another kind in the Thames. A companion of mine swam up the river with the tide from near London Bridge. Myself and others, after more moderate exercise of the same kind, kept near him in a boat, and at our entreaty he got in between Westminster Bridge and Vauxhall; he swam boldly and high, and with skimming the soot from the surface for that distance, his breast, neck, and chin, were completely painted. Indeed, all who have swum in the Thames must have observed how quickly the skin is discoloured by even a short immersion. Among the refinements introduced by

the Chelsea Waterworks Company, is the plan of sweeping the Reservoir twice a day with a rope, to remove particles of soot and floating dust before there is time for them to subside.

Conformably with what I have before stated, as to the desirableness of having water intended for common drink not only free from all unpleasant flavour, but actually agreeable from its briskness, I should lay much stress in the choice of water for that purpose, upon its condition in this respect. I need scarcely remind you of the critical nicety with which established water-drinkers regard the fluid they employ; they can, I believe, discern by the palate, differences between one spring and another more minute and less obvious to the uninitiated than those between the produce of different vineyards and seasons to the most curious in wines: and the most acute among mere judges of malt and hops must, in comparison with the water-drinker, yield all pretensions to minuteness of discrimination. I have occasionally known an instance where one who, at home, partook readily of wine or beer, confined himself to water when travelling, to avoid the change of flavour and the risk of downright bad fermented liquors. But I have known more of those who, generally taking water at home from choice, and not compelled by health or scruples, were so attached to the one chosen spring, that when that could not be obtained, they drank no water unmixed, but when abroad substituted either malt drink or water variously flavoured by other additions. The fiery stimulus, which after its various corruptions in nature and in name, from Geneivre, a spirit distilled

from Juniper, down to the compound of Alcohol and Turpentine by which so many are ginned into poverty, misery, and crime, was first introduced among the Dutch to cover the insipidity or the nauseousness of the water of their languid canals.

In some countries where the water is of bad flavour, a slight infusion of some bitter herb answers the purpose of concealing it. Now among waters not sufficiently loaded with saline matter, for this to betray itself to the palate, those will be the most sparkling and the most agreeable which contain most Carbonic Acid Gas.

Some constitutions, and some diseases may, no doubt, require freedom from saline and especially from earthy impregnation, even at the risk of being positively disagreeable to the taste; but if I am not stepping out of my province, I would suggest whether, as a general direction to persons in health, it is not preferable to drink such water as by the slight and imperceptible stimulus of its gaseous contents, gives tone to the stomach while it gratifies the palate, rather than in the search after pure water to fix on such as either naturally, or from distillation, has parted with its gases together with its salts, and has become flat and spiritless, if not disagreeable or disgusting. Purity is a term often altogether comparative; the vast laboratory of the animal frame, containing in itself a dozen or a score of elements, and with powers and functions to eliminate from these a hundred combinations and a thousand mixtures, will furnish from its own stores, and by its own operations, in spite of all our attempts to exclude the materials, or control their arrangement,

compounds so unexpected, so abundant, and so unaccountable, as almost to lend a colour of plausibility to the notion which, at times, has its advocates or apologists, that the vital powers could not only combine, but create, not only re-arrange, but transmute. Very small, therefore, would be my expectations of good or evil to the healthy frame from the insensible operation of portions of Chlorine, Sulphuric Acid, Lime, Soda, or Magnesia, in our drink, which, however carefully excluded from that means of entrance, must be still more freely introduced among the most simple of solid food; while I should hold the imparting of tone to the stomach which may so reasonably be expected from brisk and sparkling water, and the avoiding the contrary effect from that which is dead and flat, as real and substantial benefits.

I recommend then, for general purposes, water as pure as possible, in preference to any impregnation, however advantageous for particular uses; with the single exception of drinking water, for which purpose I would sacrifice softness to the effects of the Gases. I place much dependence on filtering, imputing to an earthy filter considerable chemical as well as mechanical power of separating many substances. Lastly, Iron is particularly objectionable; then earthy salts, and among these Sulphate of Lime in particular, while the Alkaline Salts, in the ordinary degree of strength, are of little importance.

A DESCRIPTION

OF

THE INTERNAL STRUCTURE OF VARIOUS LIMACES,

FOUND IN THE NEIGHBOURHOOD OF LEEDS;

BY THOMAS NUNNELEY:

READ NOVEMBER 14th, 1834.

In presenting the following account of the anatomy of Limaces, found in the neighbourhood of Leeds, to the notice of the Society, it is not my intention to enter at any length into the natural history of these animals, nor to follow them through the various localities which have been assigned to them in the Zoological classifications of different naturalists; but rather to give a minute description of their internal organization, which hitherto, so far as I am able to learn, has not been done in a satisfactory manner. The arrangement of them, now adopted by Zoologists, must rather have been determined from their external characters and habits, than from an accurate acquaintance with their minute anatomy.

Following Lamarck and Cuvier in nearly all later arrangements, the Limaces have been placed among the Terrestrial Pulmonifera near to the Helices. M. de Ferussac, in his Tableaux Systematiques, entirely

agrees in the propriety of this locality, yet differs from them in considering Limaces not merely as a genus, but as a family, which includes two genera, Arion and Limax. This division into two genera he founds upon some external differences, as the possession or not of a mucous pore at the posterior extremity of the body, the difference in the consistence of the earthy plate contained within the shield, and the relative position of the respiratory and genital orifices. In this division Ferussac has been supported by Latreille; but most naturalists, and among others, Blainville and Deshayes agree with Cuvier and Lamarck, in considering these differences not sufficient to authorise the distinction into the genera of Arion and Limax: and were there no other than these exterior differences (although as far as my observation extends, they are constant) probably few would be inclined to multiply generic divisions on their account.

There are, however, differences so constant and uniform in their internal organization, and that not merely in one or two parts, but in the Nervous, Muscular, Vascular, Digestive, and Generative systems, that if in classifications internal structure is to be taken into account, no doubt can exist as to the propriety of a separation into three or four *species;* but unless a greater difference should be found in the structure of those Limaces not seen in this neighbourhood, than in those species whose habitat it is, it does not appear necessary to make a division of the genus, which I conceive should never be done without very evident reasons, the term species as

now employed being sufficiently distinctive—the unavoidable number of generic divisions is already great enough to burden the most retentive memory.

In proceeding to give a detailed account of the anatomy of the various organs, I shall commence with the exterior character and general envelope, then pass to the muscular, alimentary, circulatory, nervous, and generative systems. Although part of the following description, has been for a long time known principally through the labours of Swammerdam and the investigations of Cuvier, I am under the necessity of describing all the organs, even at the risk of repeating what is already known, in order that the differences between the species may be better understood, and some discrepancy in the accounts given by Cuvier and Blainville reconciled. For what is already known, the article Limace in the Encyclopædia Methodique, Historie Naturelle des Vers. Tome 2, Part 2, may be consulted.*

* The preparations from which the drawings are taken were all made before I had read any descriptions of Limaces. I afterwards procured the number of the Encyclopædia above referred to and again went over my dissections, and subsequently to reading this paper before the Society, and presenting the preparations to the Museum, I have seen Swammerdam's account, and his plates, in the Biblia Naturæ, and Cuvier's excellent article contained in the seventh volume of the Annales du Museum. Cuvier's investigations are very precise, and, for the most part correct, but they are confined to the first species, Limax Ater; nor does he appear to have been aware of the differences between this and the other species, except that the penis of the Limax Maximus does not, in its interior, resemble that of the Limax Ater.

EXTERNAL GENERIC CHARACTERS.

The body of Limaces being unprotected externally by a calcareous covering, and consisting of soft parts which are very contractile, varies considerably in its shape; it may, however, be described as of an oval form, more or less elongated, more obtuse anteriorly than posteriorly, where it terminates either in a keel-shaped or rounded tail. The back is convex, forming rather more than a half cylinder, broadest anteriorly, where is situated an oval, thick, fleshy disk, more or less separated from the rest of the skin, and under which the head is retracted; this is the shield, and it contains the rudimentary shell. The foot upon which the animal crawls is flat, and extends throughout its whole length; its anterior edge is free, being separated from the neck of the animal by a furrow; it is marked in the middle by a longitudinal riband like fasciculus of fibres, and at its sides by transverse ones; it is thick, flat, and in some Limaces broader than the cloak or upper surface with which it is united at the sides, thus completing the bag containing the viscera. There is no distinct separation of the head from the rest of the body; the integuments which cover it are much thinner than those which envelope the body, and at the will of the animal it may be much extended or quite retracted under the shield; upon it are situated two pair of tentacula, they are cylindrical, contractile, and somewhat swelled at the extremity, the upper pair is much the larger, and terminates in a black point, the eye. The lower pair, though ter-

minating in an enlargement at the extremity, is not furnished with any trace of an eye. The mouth is placed between the four tentacula, and contains in its upper margin a corneous tooth; the under margin is slightly cleft in the middle. On the right side of the body are three openings. The largest, which is the respiratory orifice, is situated at the edge of the shield: the second is at the posterior and upper margin of this first orifice; it is the anus: the third is either placed directly under the pulmonary opening, or immediately behind the upper tentaculum; it is the exit for the organs of generation.

The skin of all the species is thick, very sensitive, contractile, and constantly moistened by a viscid mucous, which, on the application of any stimulus, is poured out in great abundance; indeed so freely is the mucous poured out when the animal is subjected to the galvanic battery, that the substance of the cloak is diminished by nearly one half. By long continued boiling, the skin is rendered thinner, but not dissolved, nor does the water give the slightest trace of gelatine: it apparently consists of albumen or fibrine, and mucous.

EXTERNAL SPECIFIC CHARACTERS.

First Species.

All the Limaces which I have yet examined, may be reduced to four species: the first is by far the most extensively distributed; it is the Limax *rufus*, Limax *ater*, Limax *succineus*, Limax *subrufus*, and Arion *ater* of Authors. It is found of

nearly every shade of colour from a deep black to red, which variation I conceive to be occasioned by habitation and food, as in fields it is nearly always of a deep black, while in gardens, where the food is more various, it is found of various colours: perhaps the name of Limax *ater* is the best. It is broader but not so long as the second species, it is stronger, and the skin is of a much coarser texture. The cloak is marked externally by interrupted longitudinal lines separated from each other by deep sulci; these lines are arranged with considerable regularity. The shield is studded with minute granular dots. The foot at its junction with the cloak projects on either side, presenting a rounded border, which is marked by transverse lines alternately yellow and black. At the tail, where there is a large lacuna, from which mucous is very copiously poured out, the foot is prolonged beyond the cloak. The respiratory orifice is placed *anterior* to the middle of the shield, with the genital opening directly underneath it. The tentacula are not so long or tapering as those of the other species; when touched, it rolls itself into a more globular form, and lives much longer in water.

Second Species.

The second species is the Limax *cinereus*, Limax *maximus*, Limax *anticorum*, Limace *grise*, *grey snail* of Authors. If I might presume to add another name to the already superabundant catalogue of synonymes, I would suggest that of Limax *maculatus*, as more descriptive of its appearance. It

is the most beautiful of the Limaces. It is of a reddish brown colour, with four longitudinal stripes of black, more or less continuous down the body. The skin is covered with small rugosities; these are arranged with considerable regularity in lines, which converge towards the tail. The shield is irregularly spotted with black, and is not so round posteriorly as that of the first species. The neck, when the animal crawls, is considerably projected, the skin covering it is very delicate, and marked superiorly with two or three faint-coloured lines. It is the longest of the Limaces, (sometimes when extended measuring six inches) but it is not so broad as the Limax ater. It is of a cylindrical shape, without the projecting edges of the foot; and there is no lacuna at the tail, which is keel-shaped. The respiratory orifice is *posterior* to the middle of the shield. The genital opening is immediately below and behind the right upper tentaculum. The tentacula, particularly the upper, are longer than in the Limax ater; the animal is more active in its movements, and when irritated, spreads out its shield; the mucous is not so viscid, nor do they live so long in water, apparently suffering more than the first species does, when placed in this fluid.

Third Species.

The third species, so far as I am able to judge, is the Limax *variegatus*, Limace *tachetée*, Limace *blonde des caves*. It is commonly found in cellars and dark damp places. It is of a grey colour, with pale yellow spots, particularly on the upper part of

the cloak; in its other characters it differs but little from the second species, except that it is not so large nor is its tail quite so keel-shaped.

Fourth Species.

The fourth is much the smallest of the Limaces which I have yet noticed, and for a considerable time I neglected to examine its interior structure, mistaking it for the young of one of the other species; observing it, however, to continue of the same size during the whole of the year, I was induced to examine it more particularly, and find such differences in its organization as to entitle it to a distinct description and name. It is the Limax *agrestus*, Limace *agreste*, Limax *cinereus immaculatis*, Limax *reticulatis*, Limax *filans*. When fully extended it measures about an inch and a half in length, it is narrow and somewhat keel-shaped posteriorly. The shield is large in proportion to the size of the animal, being extended over nearly half its length, and it is of an oval shape; the edges of the foot do not project beyond the cloak, which is furrowed with interrupted longitudinal lines, the shield with nearly circular. When irritated it pours out a milky white mucous. It is marked with brown spots, on a greyish white ground. The respiratory orifice is *posterior* to the middle of the right edge of the shield, the genital opening is immediately behind the upper tentaculum of the same side; this latter orifice is sometimes difficult to distinguish, appearing as a minute papilla. The upper tentacula are much larger than the lower, which are very short and small. The animal is active

and hardy, appearing in the cold weather long after the larger species have quite disappeared.

LOCOMOTIVE APPARATUS.

The locomotion is similar in the four species, and is principally, if not wholly, performed by the foot; this, on its inferior surface, is marked by strong transverse fibres: in the second and third species these fibres are more apparent at the sides of the foot than along its centre, while in the first species they pass completely across it. Progression is, however, performed by a pair of muscles which extend from the tail to the fore part, running along the middle of the foot. On opening the cloak they are seen projecting on the interior surface of the foot as two raised lines, larger before than behind. By putting a Limax of the second or third species into a bottle partly filled with water, the regular contractions of these longitudinal muscles are best seen. In the shield and cloak, though both are very contractile, nothing like distinct fibres are perceptible until after long maceration in spirit, when their substance is seen to be made up of delicate fibres interlacing with each other, and passing in all directions, except about the neck, where they exhibit a more distinct longitudinal arrangement, and some are continued to be reflected upon and in part form the fleshy walls of the buccal mass.

PROPER MUSCLES.

The muscles destined to the motion of particular organs have in the four species this common character, viz. that they all arise from the interior surface of the cloak, near to the margin of the diaphragm, but in none of its systems does the first species differ more from the others than in the muscles belonging to particular organs. In the former there are four muscles, while in the three latter there are only two, which are distributed to the same parts, and answer the same purposes as the four.

First Species.

The first muscle is the retractor of the buccal mass, or pharynx; it arises from the cloak rather to the left of the median line, and at a little distance from the diaphragm it is very slender, and passing forwards soon divides into two branches, one of which is inserted into each side of the buccal mass.

The second and third muscles are a pair exactly resembling each other, the one belonging to the right, the other to the left tentacula. To describe one will therefore be sufficient. It arises by two heads immediately behind the diaphragm, directly at the inner side of the venæ cavæ; the two heads soon unite (there does not appear to be any mingling of their fibres) and again divide into two branches, the one passing to be connected with the extremity of the larger tentaculum; the other branch again divides, one division going to the smaller tentaculum, the other to be inserted into the integuments near the lips,

after having received a small fasciculus from the branch belonging to the larger tentaculum.

The fourth muscle belongs to the organs of generation, and supplies the means of retraction after their projection from the common cavity during copulation; it arises at the edge of the diaphragm on the left side of the body, is short, and passes obliquely forwards towards the right side, to be inserted (after having sent a few fibres to the vagina and neck of the vesicle) into the lower and posterior corner of the muscular cavity which is common to the vagina, penis, and vesicle; from it a few fibres are also continued along the common cavity (the cloaca) to the integuments, which, by projecting the cavity, may oppose the other portion of the muscle.

Second and Third Species.

In the second and third species the muscles are the same in number and form—there are only two. The first supplies the place of the three in the first species, being the common retractor of the buccal mass and tentacula. It arises by a single origin, exactly in the centre of the cloak, immediately behind the diaphragm; its fibres may, however, be traced by their glistening appearance some distance down the back. The muscle passes forwards, and soon divides into four branches; the two middle ones belong to the buccal mass, being inserted one on each side into the posterior part of it. The two exterior divisions belong to the tentacula. Each of these divisions is distributed in a very similar manner to the proper muscles of the tentacula in

the first species—the principal branch joining the larger tentaculum, the other, after sending a slip to the lips, the smaller tentaculum.

The second muscle belongs to the penis; it arises from the cloak on the left side: at the edge of the respiratory cavity it is short, and passes forwards and towards the right side to the apex of the penis, where it is inserted close to the opening of the vas deferens. The only difference in this muscle is, that in the Limax maculatus it is stronger, and not quite so long as in the third species.

Fourth Species.

In this, as in the second and third species, there are only two muscles, the distribution of which is similar. The first arises by two roots, the one in the middle, the other a little to the right (and sometimes there is a third minute fibre) from the cloak immediately behind the diaphragm; this muscle splits into two branches, one branch again dividing, is inserted into the buccal mass, forming its retractor muscles. The other branch belongs to the tentacula; it also divides to join the tentacula on each side, —the principal fasciculi going to join the larger, and, I believe, the smaller, the lesser tentacula, but from their minute size, and passing in close connection with the nerves issuing from the ganglion, it is difficult to say if they are nerves or muscles.

The second muscle is proper to the penis, it arises by a broad origin from the fore part of the diaphragm, commencing in the median line, and extending as far as the left side of the respiratory

cavity; the middle of this attachment is thinner than the two sides, and by forcibly extending it, may be made to appear as having two distinct origins, the one from the centre, the other from the left side. It passes forwards and to the right side, and is inserted into the triangular penis, not into its apex, but about its middle.

In addition to these muscles, there are in the four species fibres seen passing from the envelope to the buccal mass. These are more evident on the under part of this mass, when it is reflected forwards, and sometimes are so evident as almost to deserve the name of distinct muscles.

DIAPHRAGM AND RUDIMENTARY SHELL.

Limaces possess two cavities, a pulmonary and an abdominal. On opening a slug along the foot, the whole interior of the envelope is found to be lined by a fine thin delicate membrane, which invests the viscera; in most parts it is little more than cellular membrane, but at the place where the shield joins the cloak it becomes much thicker and stronger, and divides into two layers. One of these passes under the respiratory cavity and heart, which it separates from the abdominal viscera, thus forming the *diaphragm.*

The other, which is not so membranous, lines the shield, forming the upper surface of the pul-

monary cavity, and encloses the rudimentary shell. This shell is placed in the centre of the shield, immediately over the heart, and is interior to the cutaneous envelope. In the first species it is composed of loose earthy particles, which can scarcely be said to be connected together, while in the second and third species it presents a miniature resemblance to a valve of a conchiferous animal, and is as evidently as it, formed by a superimposition of earthy laminæ, united by animal matter. In the fourth species it is still more minute, but of a similar formation.

ALIMENTARY SYSTEM.

First Species.

Lips and Tooth.—The mouth is placed at the fore part of the head, between the tentacula; when closed, it presents little more than a longitudinal slit, but when opened, it is nearly circular. The margins of it have been called lips, though they are not distinct organs; the upper has attached to it a curved corneous tooth, over which the cuticle passes into the mouth, and with which it is readily detached. The tooth is formed of a great number of horny fibres, arranged parallel to each other; the alternate fibres being long and short, a finely senated edge is produced.

Buccal Cavity.—The lips open into a cavity which has been called the buccal cavity, or pharynx;

it is formed of strong muscular walls, and is nearly filled by the tongue, which is, however, at the same time, the principal organ of mastication, the lower jaw, and the sole organ of prehension. It is somewhat of a horse-shoe shape, with the circular part opposite to the corneous tooth in the upper lip, and the two rami passing backwards. It is covered by a firm, dense, almost cartilaginous membrane, under which is the strong muscle of which it is formed.

The muscular fibres of the tongue do not terminate abruptly, but each ramus divides into two portions:—The fibres of one pass downwards and forwards, and in conjunction with those of the corresponding fasciculus from the opposite side, assist the fibres from the retractor muscle and general envelope, in forming the inferior part of the buccal walls, and the depressor of the tongue. Those of the other portion pass backwards and upwards, and in like manner assist in forming the upper part of the buccal walls and the elevator.* Immediately behind the tongue is a small white, dense cylindrical body, which also projects behind the cavity; its use I am unable to determine, unless it be to assist in the motions of the tongue, with the cartilaginous covering of which it is connected, but not with the muscle itself.†

Œsophagus, Stomach, and Intestine.—From the

* By keeping a Limax some hours without food, and then placing a small pellet of bread near the edge of the mouth, just so that the animal cannot seize it, in the efforts which it makes to reach the bread the motions of the tongue are very well seen.

† Cuvier supposes it is the motion of this small body which produces the motions of the tongue itself. Vide Annales du Museum, Tome 7.

buccal cavity arises a short, narrow membranous œsophagus, which soon dilates into a large cylindrical stomach, about three inches long; this, when the animal is extended, passes backwards in nearly a straight line, and terminates in a round cul de sac, a little anterior to which is the pylorus, where the intestine commences. The intestine is of an equal calibre throughout, about six inches long, and forms two complete convolutions: the first convolution being as it were together with the uterus, looped up by the anterior division of the aorta winding round them; it terminates in the rectum by piercing the diaphragm and passing immediately above the vascular expansion of the pulmonary cavity, to the edge of the respiratory orifice, where it opens with the outlet of the organ of mucosity. The whole alimentary canal is formed of two delicate transparent membranes, the inner of which, in the stomach and œsophagus is, when they are empty, thrown into longitudinal folds. In the œsophagus and about the pylorus, there are faint traces of muscular fibres.

Liver.—A considerable portion of the visceral cavity is occupied by the liver. This organ is very large, and consists of two lobes, an anterior and posterior. The anterior lies between and in part envelopes the stomach and intestines, the posterior fills the hinder part of the sac. Each lobe consists of minute lobules of a dark brown colour; from each of these lobules arises a small duct, which, by uniting in the middle of the lobe, constitute a very considerable biliary canal. The two canals open into the stomach near the pylorus: the one from the

anterior lobe on one side, that from the posterior on the other, by orifices so large, that water or mercury injected into the stomach, readily finds its way into the lobules of the liver, and by inflating the stomach by means of a blow-pipe, the liver resembles the inflated lung of a frog. This organ is very freely supplied with blood.

The *Salivary Glands* are situated at the under part of the œsophagus and commencement of the stomach; they are two white granular bodies; from each proceeds a minute duct, which opens into the back part of the buccal cavity.

ALIMENTARY CAVITY IN THE SECOND AND THIRD SPECIES.

The tooth, which is alike in the second and third species, differs considerably from that in the first; instead of forming a finely serrated edge, it is divided by two deep notches into three portions.

In the other parts of the digestive system, as the mouth, œsophagus, stomach, liver, and intestines, until near the termination of the latter, little difference in the species exists; but in this part, the second and third species not only differ from the first and fourth, but also from each other. Indeed, were it not for the difference seen here, these two slugs so nearly resemble each other in their organization, that the separation into distinct species would be improper.

In the second species, Limax maculatus, there is an additional loop of intestine. When the gut has reached the retractor muscle, common to the

pharynx and tentacula, instead of terminating in the rectum, and passing under the shield, it forms a loop, running down the cloak nearly as far as the tail; the ascending portion of this loop is considerably dilated. A larger portion of the rectum is enveloped by the vascular tissue, than in the first species; and immediately before it terminates in the anus, it forms a small cul de sac on one side.

In the third species, Limace blonde des caves, instead of this fold, there is a single process, into which the intestine opens, and from the opposite side arises the rectum. This process, at its commencement, is large; but gradually tapering to a point as it runs down the cloak, it is lost near the tail; it consists of but little more than delicate cellular tissue, is always collapsed, nor do the fœces pass down it: by introducing the blow-pipe into the intestine it may be distended—the air, however, soon escapes. The fœces, it would seem, merely cross the upper part of this process, in passing from the intestine to the rectum; this latter is enveloped by the pulmonary tissue, for about the same extent as in the third species, and like that, previous to its termination, forms a small cul de sac.

ALIMENTARY SYSTEM IN THE FOURTH SPECIES.

In the fourth species, the alimentary system consists of the same organs as in the other species. The corneous tooth is of the same shape as is seen in the second and third species, nor do I know of

any difference worth notice existing, except of course the much smaller size of the parts, and perhaps a somewhat greater proportional development of the salivary glands, until we come to the termination of the intestine, which, instead of forming either a double or single process upon the cloak, passes at once above the respiratory cavity, as in the first species, being covered, however, by the vascular expansion, to the same extent as in the second and third species.

CIRCULATORY SYSTEM.

In the four species the organs of circulation consist of the same parts differently disposed.

First Species.

In the first species, the heart is placed in the centre of a spongy ring, immediately under the earthy particles within the shield. The *heart* is contained in a pericardium. The venous blood is returned to the heart by two venæ cavæ, which run one on each side within the cloak; they commence quite at the caudal extremity, receiving branches in all directions; they pass forwards to the place where the shield joins the cloak, where also the diaphragm, which separates the pulmonary cavity from the viscera, is attached. They here communicate, forming a vascular ring, from which the *pulmonary veins* arise;

these ramify on the upper and inferior surfaces of the respiratory cavity, forming a most beautiful and delicate expansion, particularly on the *left* side and *fore part* of the cavity, where they are the most freely distributed. Those on the upper surface, after being collected into four or five principal trunks, run as far as the spongy ring, where they apparently are joined by those from the inferior surface, which pass up to them on the sides of this ring; from this point expanding, they form, on the *left* side, an exceedingly transparent thin auricle, which communicates with the base of the ventricle, by a small opening, placed anteriorly, and in the median line at this opening, the blood is prevented from regurgitating, by two valves, formed of the lining membrane of the heart. The ventricle is pear-shaped, with the base placed upwards and forwards, while the apex is inclined downwards, backwards, and to the *right* side.

The ventricle is decidedly muscular, having more resemblance to this tissue in the higher animals than any other part of a Limax. The inner surface is irregular and unequal, reminding one of the columnæ carneæ. From the apex arises the single aorta, which immediately passes through the diaphragm, and divides into two branches of nearly equal size. The descending or posterior branch joins the stomach, down the right side of which, in company with the oviduct, it passes, sending out very numerous branches, to the intestines and anterior lobe of the liver; at the pylorus it divides into two branches, one of which passes on each side of

it, to the posterior lobe of the liver and ovary, where they are distributed.

The second division may be called the ascending or anterior aorta; it at first passes round a loop of intestine and the uterus, then turning forwards, it runs towards the mouth, where, dividing into branches, it is lost. In passing round the uterus, two branches are given off, which run in opposite directions along the concavity of this convoluted organ: the one branch supplies the testicle, the other the penis and vesicle.

The third branch given off by the anterior division is destined to supply the cloaca; from it a minute twig is given off immediately behind the shield, and may be traced on the cloak as far as the tail; the other branches are the terminating, and supply the head, neck, buccal mass, &c.

The arterial blood appears to pass into the veins by an immense number of capillary vessels. The arteries may be injected with turpentine or quicksilver, but are best seen by cutting open the Limax ater while alive; they are then found beautifully distended, and of a white colour: particularly the branches of the posterior vessel.

CIRCULATION IN THE SECOND AND THIRD SPECIES.

The general distribution of the arteries and veins, until we come to the pulmonary cavity, is the same, so far as I am able to judge, in all the species, but in this cavity a considerable difference is perceptible.

In the second and third species the heart is not

placed in the centre of the spongy organ, but is more confined to the left side; nor are the pulmonary veins so freely distributed over the greater part of the cavity, but are principally spread upon the *right* side and fore part, from whence, after being collected into one large trunk, they expand directly into the auricle, which is large and perfectly transparent; it is easily to be seen both in the living and dead state, projecting before the ventricle; besides the large venous trunk, a few small veins open into the auricle. The ventricle inclines much to the *left*, the apex being quite on the *left* of the cavity, while in the first species it is towards the *right* of the cavity.

In the first species it has been said that the heart is placed in the centre of a spongy ring: this is called by Cuvier "organe de la viscosité," and by Blainville "organe de la dépuration urinaire." It forms a complete circle, surrounding the pericardium; it is composed of a smooth transparent membrane, inclosing a great number of reddish brown fibrilæ, attached by one extremity, free at the other; when viewed with a lens, they appear to be hollow tubes, much resembling a piece of fine sponge; the excretory canal opens at the side of the anus.

In the second and third species, instead of forming a ring in the centre of the respiratory cavity, it is a roundish mass, inclosing the ventricle alone, and it is situated on the left of the cavity; its excretory canal is longer, but in other respects the same. No doubt can, I think, be entertained of the use of this organ. On touching the respiratory orifice, at

the margin of which both this canal and the anus open, a large quantity of limpid mucous is poured out, serving evidently as a means of defence against the ingress of other animals.

Fourth Species.

So far as I am able to ascertain, there is no perceptible difference in the circulation of this and the two preceding species; the heart is similarly placed, as is the distribution of the arteries and veins. The mucous organ is certainly rather larger, and possibly other slight differences may exist, which, from the minuteness and transparency of the parts, have escaped my observations.

NERVOUS SYSTEM.

The nervous system in Limaces, is well developed, and presents a bilateral symmetry; it consists of a ring of nervous matter, in which are two ganglia, surrounding the œsophagus, and numerous branches distributed to the organs of motion, and to the viscera.

First Species.

One of the two ganglia is placed above, the other below the œsophagus.

The supra-œsophageal ganglion has not improperly been called the cerebral ganglion; it is

situated immediately behind the buccal mass, it is narrowest in the median line, and enlarged at the sides, from each of which proceeds five or six branches. 1st.—A very minute twig to the buccal mass. 2nd.—A large branch to the upper tentaculum, (the optic nerve); this branch is much convoluted when the tentaculum is retracted, and it may be distinctly seen passing in between the muscular fibres, which divide for its passage. 3rd.—A small branch to the lips. 4th.—A large branch which divides into two, one division going to the smaller tentaculum, the other to the fore part of the head. 5th.—The band which passes round the œsophagus, forming the sides of the nervous ring; to join the infra-œsoghageal ganglion, this band sometimes (after long maceration in spirit) appears to consist of two or three smaller fasciculi.

The inferior ganglion is the largest: it is of a square form, and being slightly fissured both transversely and longitudinally, it apparently consists of four ganglia united together; it also consists of two laminæ, between which, in the median line, a probe may readily be passed; they are, however, closely connected together at the sides, (is there any analogy between these two layers and the anterior and posterior spinal columns in higher animals?) From the superior of these two laminæ of the infra-œsophageal ganglion, two or three branches arise on each side, and pass to the organs of generation, the respiratory cavity, and abdominal viscera, while from the inferior laminæ and conjoined edge, several (about ten on each side) branches arise; they, for the most

part are short, and are distributed to the anterior part of the animal; the last of these branches is, however, of large size, and runs upon the foot as far as the tail, distributing many branches to the foot and cloak. It is not in contact with the viscera, but lies immediately upon the foot, being separated from the viscera by the delicate membrane, which was before spoken of as lining the whole of the envelope.

The inferior ganglion consists of a homogeneous structure like the nerves. The superior differs from it, in having its central portion of a less firm and more granular character.

Second and Third Species.

The nervous system is alike in the second and third species; it consists of the same parts as in the first. The supra-œsophageal ganglion is rather more connected to the upper tentacula, the optic nerves being shorter; its sides are more enlarged, and the band which unites it with the inferior ganglion more frequently consists of separate fasciculi. The nerves arising from it are similar to those in the first species.

The infra-œsophageal ganglion, in place of having one transverse fissure, has two, so that it presents on each side of the median line, three gangliform eminences, instead of two only. Of these, the anterior is the largest, the posterior the smallest; it is the inferior only of the two laminæ of which this ganglion consists, that presents these eminences. The nerves arising from them are similar in number and distribution to those in the Limax ater.

Fourth Species.

I believe the ganglia and nerves are very similar in this, to those of the second and third species. The supra-œsoghageal ganglion appears more like a simple cord, and is more closely connected with the upper tentacula; it is also of a rather brown colour, partaking of that of these organs.

The eminences of which the infra-œsophageal ganglion consists, are more loosely united, particularly in the median line, in this small species than in the larger. In this, as in fact must be the case in all the Limaces, the nervous ring, in consequence of its close connection with the tentacula and other parts, is subject to considerable variation in its position, being carried forwards or backwards according as the head is projected or retracted.

GENERATIVE SYSTEM.

It now only remains to describe the organs of re-production, or the generative system. And here a remark which has before been made, may be repeated, that the same, or nearly the same organs, are found in all the species, it being only upon an attentive examination that any peculiarities are seen to exist; differences do however exist, and those of an important character.

The Limaces, like the Helices, are hermaphro-

dite, both impregnating and receiving impregnation at the same time. The organs consist of an ovary, oviduct, uterus, vagina, testicle, epididymis, vas deferens, penis, and vesicle; to this list, in the first species, may be added a common cavity called the cloaca. As before, I shall take the Limax ater as a type, and afterwards notice the differences existing in the other species.

First Species.

The *ovary* is embedded in the posterior lobe of the liver, having the continuation of the posterior arterial branch passing through a sulcus in it. It is about the size of a large pea, and is composed of granules of a dark, reddish brown colour. These granules vary in colour, being of a deeper or lighter shade, according to the colour of the animal; under the lens, they are seen to be clusters of ova, contained in a transparent membrane, of which membrane the oviduct is apparently a continuation.

The *oviduct* arises by small ramifications, which uniting, form a slender convoluted tube, with thick, opaque, white walls, about two inches long: it proceeds in company with the posterior aorta, gradually enlarging and becoming more convoluted as it passes forwards to the anterior part of the testicle, where it opens into the commencement of the matrix, or uterus.

The *uterus* is a much larger, inflected tube; when extended, it is about three inches long. The walls are composed of a thick, white, mucous-like

membrane, which, from its convoluted condition, appears as though it were alternately contracted and dilated, so as to form a succession of cellules, containing a viscid mucous: before its termination, it becomes smaller, and the cellules disappear, (this part may be called the *vagina,)* it opens into the cloaca beneath the penis and vesicle, by two singular projecting labia; between these, a probe may be passed from the cloaca into it.

The *testicle*, is a large white, oval, glandular mass, easily breaking down under the fingers, attached to the extremity of the uterus; from it, there is continued along the concavity of the convoluted uterus and vagina, a very slender granular portion, like a thin band, which Blainville supposes to resemble an *epididymis;* this, near the cloaca, terminates in a thread-like tube:—the *vas deferens*, which, leaving the vagina, passes to the base of the penis, along which it runs to the apex, where it opens. Whether the vas deferens is connected only with the epididymis, or is continued within it as far as the testicle, I am rather uncertain; occasionally, after long maceration in spirit, I have fancied I had succeeded in tracing a continuous tube, but more frequently I have only been able to trace it for a short distance, and on the whole, I am inclined to believe, that it does not extend far along it.

The *penis* is a small, muscular, convoluted, conical-shaped tube, lying above the vagina, immediately under the diaphragm; its apex is continuous with the vas deferens, and is unattached; its basis opens into the cloaca, close to the opening of the

vesicle. The penis is lined with a mucous membrane, which, at its base, is thrown into longitudinal folds.

The *vesicle* is an oval-shaped bladder, it lies near to the vagina; it contains some turbid fluid, and is lined by a membrane which is sometimes stained with red spots. By means of a short tube, the vesicle opens into the cloaca, close to the opening of the penis. At its termination at the cloaca, and at its commencement at the vesicle, the caliber of this tube is somewhat diminished, owing to the lining membrane being rather contracted and thicker at these places than in the intermediate space.*

The common cavity into which these organs open, is called the *cloaca;* it is muscular, hollow, of a quadrilateral form, connected with its retractor muscle before described. It is continued to the

* The vesicle is enumerated among the female organs; in the third species it certainly is more connected with the female than with the male, but not in the others. Why it should be classed with the female rather than with the male, unless from analogy, I do not know; its use I am quite at a loss to conceive. It will be observed, that throughout this paper I have employed the terms which have been imposed upon these various parts by naturalists, from the supposition that they correspond in function with the parts in higher animals, whose names they bear. How far the opinion is correct, which is entertained by some eminent zoologists, (among others I believe by Dr. Grant), that all these animals are only female, and not hermaphrodite, perhaps remains to be proved. The probability of it would seem to be much strengthened by the consideration, that in earliest fœtal life, all animals are female, and that the development of parts, into male organs in distinct indiduals, only occurs in the higher grades. These hermaphrodite creatures would then occupy an intermediate station between the lowest animals, who, for the purposes of re-production, do not require communication with another, each possessing a power of self-fecundation; and those more perfect orders, where copulation is necessary, but the one only impregnates, the other is only impregnated; while these animals, on the contrary, possess in themselves the necessary apparatus for both purposes, but require mutual assistance in performing this function.

external aperture, by a narrow ring, consisting of small granules of a yellow colour. On cutting open the cloaca, its cavity is found to be principally occupied by the two labia of the vagina; the penis may also be seen projecting into it, with a small aperture in the centre of this nipple-like projection, adjoining to which the vesicle opens.

If differing from the course which has hitherto been followed, of describing the second after the first species, we pass to the third, it will save some needless repetition.

Third Species.

The *ovary* in general occupies the same position as it does in the first species; sometimes, however, it is found near the testicle;* it is of a more elongated form, rather larger, and the ova are of a pale, yellowish white colour.

The *oviduct* precisely resembles the first species. The distinction into uterus and vagina is here well marked and evident.

The *uterus* is convoluted as in the first species, but it is shorter; its walls are thicker, and its caliber more considerable; it terminates very abruptly

* This displacement is probably occasioned by strong contraction of the fibrous envelope. Does not this displacement always occur during copulation? Of the exact state of the parts, during the act of coition, very little is known. I have set more than one person to search for Limaces when in this condition: unfortunately the parties have not been very successful in finding them, and those which have been found, have been disturbed. By a little care, they may be destroyed without separation. Another season, I hope to succeed in obtaining some specimens.

in the *vagina*, which is a small, straight tube, formed by a thin membrane about an inch and a half long, opening without the intervention of a cloaca, immediately under the right large tentaculum, in common with the penis.*

The *vesicle* in this species is more connected with the female organs than it is in the Limax ater; it is of the same size, and opens into the vagina (which is slightly dilated at the part) at a short distance from the termination of the latter organ.

The *testicle* is similar to that in the first species, with its slender granular prolongation continued down the concavity of the uterus and vagina; as it passes along the vagina, the epididymis gradually becomes rather larger, and may readily be separated from it, the two being only loosely connected together. The epididymis terminates in the *vas deferens*, which passes to the apex of the penis.

The *penis* is much larger in this species, and its apex is attached to the retractor muscle. The walls are evidently muscular, and on laying open the cavity of it, there is seen nearly in its whole length, a small convoluted projection. The penis opens in common with the vagina, these two organs uniting just at their exit, so that properly speaking there is no cloaca.

Second Species.

The points on which the generative organs in the second species differ from those in the third are

* The uterus in this species swells and enlarges remarkably by being in water or weak spirit for a few days; its structure is then very well seen.

—*first*, that frequently, but not invariably, the testicle is found to be exceedingly small and shrunk, —*second*, the uterus is not so large—*third*, the penis is considerably larger; the longitudinal projection within its cavity is of a greater size and more helixiform shape—*fourth*, the muscle attached to its apex is not quite so long—*fifth*, the vesicle is so small and closely connected to the vagina as often to render its existence doubtful—and *lastly*, instead of its tube opening into the vagina, it opens into the angle formed by the junction of the base of the penis with the vagina.*

Fourth Species.

The *ovary* in the fourth species is large; as in the other species, it consists of a congeries of ova enclosed in a transparent membrane; they are, however, of a larger proportional size, more oval shape, and of a dark, purplish brown colour.

The *oviduct* is about half an inch long, and opens into the commencement of the uterus.

The *uterus*, *vagina*, and *vesicle* are very similar to those of the second species; the latter organ is very small and very closely connected with the vagina.

The *testicle* is large, bilobed, granular, and of a

* It might perhaps be supposed that these differences in the size of the organs, particularly of the testicle, depended upon the time of the year at which they were examined, but this is not the case. The dissections of the several species were made during the same seasons, extended over several months, and included a great number of specimens; the most singular thing is, that in some individuals the testicle should be well developed, in others very small.

brown colour: its thin riband-like portion is continued down the matrix and vagina to terminate in the excretory duct (the *vas deferens*) which passes to the apex of the penis, where it opens.

Penis.—No organ in any of the Limaces differs so much from the corresponding organ in the other species, as does the penis in this little slug from those in the preceding species; it is proportionately much larger and forms a triangular mass, with a broad base placed forwards; the apex is small, pointed, and curved towards the right; it is muscular, and situated directly under the diaphragm. The retractor muscle is not attached to its apex, but to the right side; the vas deferens opens into the apex. On laying the penis open it is found to be hollow, and, by a septum, nearly divided into two cavities. The upper of these, or that nearest the apex, is filled by a projecting body, very similar to that noticed in the penis of the second and third species, but larger. The second of these cavities occupies the base of the penis; it has not a very free communication with the upper division; like that it is filled by a triangular body: this body, in shape, precisely resembles that of the penis itself; it is free, with the exception of its base, which is attached to the walls of the penis on the left, while its slender apex lies opposite to the junction of the penis with the vagina, as they form a common opening, and during a state of excitement, must be first protruded. This small body is formed, or at least covered by a reflection of the lining membrane of the penis; it is marked by longitudinal raised lines, is hollow,

and I believe there is an opening at the apex; but from the minute size I speak with some doubt. Nothing like earthy or hard particles are found in it, so that it can scarcely be supposed to resemble in function the sac which secretes the dart in Helices.

The penis opens in common with the vagina, directly behind the right upper tentaculum, the two joining just at the exit, as in the second and third species.

In common with most of the Mollusca, Limaces possess only a limited development of the senses.

They have no organs of *hearing*.

The whole surface is very sensitive, and particularly the tentacula; but how far this should be regarded as an evidence of the sense of *touch* (if by this term is implied the faculty of acquiring some precise knowledge of the bodies come in contact with) is, to say the least, extremely doubtful.

Taste and *smell* they evidently are possessed of, since they select one substance rather than another, and are soon attracted in numbers to any favourite food, even when placed at some distance from their accustomed haunts. The precise locality of the olfactory power is difficult to determine; but I am rather inclined to suppose it resides in the tentacula, (perhaps the lower,) since, when in search of food, these organs are always extended, and in feeding, are first applied to it.

Sight.—It has long been a disputed point whether

or not Limaces possess eyes, or any powers of vision; for though Swammerdam, in his Biblia Naturæ, (Vol. I. p. 99 to 107, and Vol. II. plate 4,) has both minutely described and figured, not only the parts of an eye generally, but even the aqueous, crystalline, and vitreous humours, with the choroid coat, in the neighbouring genus Helix; later observers have denied the existence of an eye, in any form, in either Helices or Limaces. In observing the habits of Limaces for some time, I was inclined to the latter opinion; but, on more carefully examining, I was convinced that they by some means directed their course. By placing an opaque body first on one side, and then on the other, a Limax may be made to vary its course in any direction, and from the manner in which the upper tentacula are applied towards such a body, it is evident they are the organs by which it is directed. On subjecting the tentaculum to the microscope, appearances confirm this; and, after repeated and careful examinations, I am quite satisfied that they are possessed of eyes; —in order to understand which the tentaculum itself must be described.

The tentacula are hollow tubes, formed by a prolongation of the delicate integuments covering the neck; they are capable of being completely retracted within the abdominal cavity, and when so retracted, are inflected like the finger of a glove; the apices of the upper tentacula are a little enlarged, and, when fully extended, a black spot is observed upon each; these spots are also seen within the cavity when retracted.

These organs are retracted by the muscles which have been before described, (*vide* Muscular System,) and they are said to be extended by spiral fibres, which, if they exist, I have not been able to see; but in place of them there are longitudinal fibres derived from the retractor muscle.

The retractor muscle, instead of terminating abruptly at its insertion into the tentaculum, as it approaches the black spot becomes hollow; the fibres separate from each other, and enclose the optic nerve between them; they are then attached to the inverted integuments surrounding the black spot, some of them being afterwards continuous with, and closely connected to, the inside of the cutis of the tentaculum, as far as its continuity, with that covering the head, where they are lost, so that while the body of the muscle is the retractor, these latter fibres would necessarily project the organ, and supply the place of the imaginary spiral fibres.

The optic nerve arises from the supra-œsophageal ganglion; in the retracted state of the tentaculum it is much convoluted, it proceeds outwards towards the retractor muscle, into the centre of which it enters by piercing its fibres, then surrounded by them, it passes as far as the black spot, behind which, it expands into a pulpy mass.

When the tentaculum is laid open, the black spot seen at its apex is found to be a minute globule, covered by the thin transparent cutis, lying upon, and partially imbedded within the large pulpy mass of the optic nerve. It is spherical, with a

covering of a dense, black colour, in which apparently there is no aperture; but on getting under a good microscope, that portion of it which is most prominent when the tentaculum is fully extended, there is seen to be at that spot a deficiency of the black pigment, so that a ray of light may enter it, and by passing through the sphere, fall upon the nervous mass. If this choroid coat be then divided, within it is found a chrystalline lens and vitreous humour. I have not seen any aqueous humour, which if it exists, must be in such exceedingly minute quantity as to render its detection barely possible.*

The chrystalline lens is a perfect globule, and (if not an optical delusion) is composed of fibres passing from pole to pole in a similar manner to those in the lens of many fishes described by Sir D. Brewster in the Philosophical Transactions for 1833. The vitreous humour fills about half the globe, occupying the space behind and at the sides of the lens, which is imbedded within it. Thus we have in the eye of a Limax—first, the transparent cutis, which acts as a cornea, as it does in many other animals; then the black choroid coat, with an aperture in it forming the pupil, directly behind which, and enclosed within the choroid coat, is the spherical chrystalline lens and the vitreous humour; lastly the pulpy expansion of the optic nerve—all the important parts which constitute the most perfect organ.

* Swammerdam describes the aqueous humour in the eye of a Helix, and in his fourth plate it is figured in the act of escaping from the punctured eye.

There is evidently a close resemblance between the eye in these animals and a single division of the compound eye in many insects, as in that of the Libellula vulgata.

The large tentaculum, in the extended state, consists of the integuments lined by longitudinal muscular fibres, (as upon the neck the cutis is studded with minute granules,) then the hollow retractor muscle itself partially enclosing and forming a sheath for the optic nerve in its passage to the black globule at the apex of the tentaculum.*

Limaces are exceedingly voracious; they feed principally upon soft or partially decayed vegetable substances; they will, however, attack harder bodies, and in the course of time make an impression upon a piece of deal; they may perhaps be more correctly considered as omniverous than phytivorous, particularly the second and third species, which devour the most dissimilar things, even eating each other. If the different species are confined together, the second will devour the others: I have frequently seen it eating those of the third; and the young of the first species may often be seen feasting upon

* I hope this description is intelligible; a reference to the engraving will more distinctly explain what is meant. I would take this opportunity of bearing testimony to the general accuracy of most of the plates on the Cochlea, in that wonderful work—Swammerdam's Biblia Naturæ, and also of expressing my regret in not being able to obtain it until after nearly all the dissections for the engravings illustrative of this paper were made; had I, much labour would have been saved: however, the description of the eye of the Cochlea there found is a strong confirmation of the correctness of that now given of the Limax; for though Swammerdam could not perceive a pupil or any opening in the choroid coat, he says he has no doubt of its existence.

the backs of old Limaces of the same species; the cuticle is the part preferred, every particle of it being frequently removed, together with the colouring matter, from the whole cloak, so as to leave the older slug quite white; probably they are tempted to do this for the mucous, by which Limaces are constantly moistened, and of which the young appear to be exceeding fond.

The mucous, in addition to its other uses, seems to serve as a means of defence: on the animal being irritated by any foreign body, it is freely poured out; and if the pulmonary orifice, when opened, is suddenly touched, a large quantity is instantly excreted from the organ of mucosity placed within the cavity. But I here stop; I am wandering into the natural history of these animals, which is not my object at present; my intention was to confine my remarks to a description of the anatomy and difference of structure among the various species found in this neighbourhood.

ABSTRACT

OF

A NOTICE OF CERTAIN ROMAN COIN MOULDS,

FOUND AT LINGWELL-GATE, NEAR WAKEFIELD, IN 1830;

BY JOHN HEY:

READ FEBRUARY 18th, 1831.

THE clay moulds for casting Roman Coins, which have been found in various parts of England and France, have been from time to time introduced to the notice of learned Societies; and, to those who attach value to this kind of historical document, have afforded interesting matter of speculation.

The monies obtained from these moulds have been called by the French "*piéces de necessité;*" by which term it is intimated that this mode of paying the Roman soldiers was resorted to, *by authority*, when the military chest was at a low ebb, and the army at a distance from the legal means of supply.

Many, however, who have paid attention to such matters, have, in common with myself, thought it more probable that they were the implements of illegal coiners. Yet on referring to those papers which have been published on this subject in the

Transactions of the Royal Society, the Society of Antiquaries, and the French Academie des Inscriptions, I am surprised to find that an argument which to me appears one of the strongest in support of this opinion has been overlooked. I allude to the dates of those coins the impressions of which are here presented to us. But indeed no satisfactory conclusions could be deduced from these, till a sufficient number of them had been collated.

The object of this Paper was to show that the "necessity" asserted by the French never existed. The chief points which have hitherto been rested upon for this purpose are—the well known fact of the striking of Coin by the Romans; the severity of the laws against "false" or illicit "fusion;"* the high rank and responsibility of the Triumviri Monetales, or Mint-Masters, &c. It would be superfluous, upon the present occasion, to go into these questions with the minuteness which was requisite on introducing the subject for the first time to this Society: they are fully stated by Mahudel† and others. I may

* It has been thought that in the following law from the Theodosian Code, there was an allusion to an illegal imitation of the current coin by casting, and a distinction made between that and the legal striking.

"Si quis nummum falsâ *fusione* formaverit, universas ejus facultates "fisco addici præcipimus; ut in monetis nostris *cudendæ* pecuniæ studium "frequentetur."—Leg. III. Tit. 5.

Yet it is singular that the word *fuderit* does not occur in the Pandects: the words used by Sylla in the Lex Cornelia Nummaria were "Qui nummos aureos, argenteos adulteraverit, laverit, conflaverit, raserit, corruperit; quive nummos stanneos, plumbeosve emerit, vendiderit dolo malo, ei damnato aqua et igni interdicatur." The only new words in the Pandects are vitiaverit, tinxerit, and finxerit, for which last word many insist on reading *cinxerit*, the meaning of which however is not very obvious. The word "cudere" is applied to leaden coin by Plautus.—Mostell Act. IV. Sc. 2. v. 11.

† Mem. de l'Acad. des Inscriptions, Vol. II. 333.

however mention, as bearing more especially upon the view which I have taken, that whatever provision was made, whatever protection extended to the coining of money, was not confined to Rome, but was carried wherever the Roman Empire extended. Dies for striking Coin have been discovered at Nismes in Languedoc, which are figured in the Memoires de l'Academie des Inscriptions.* Lyons also was one of those stations where mints were established. But we may advance a step further than this, by the aid of historical evidence alone. In this Island, the progress which the Britons themselves had made in the art, even before the invasion of the Romans under Severus, was such as to render them independent of a precarious mode of supply. The extension of their commerce during the reigns of Tiberius and Augustus appears to have first introduced the art into this country; and the adoption of Roman characters, inscriptions, and devices, shows sufficiently from whom it was learnt. There is, in the Museum of this Society, an early British Coin which is of lead, and evidently *cast;* but I think it is universally allowed that Cunobeline's coins were struck. I have one of these in my possession, and its appearance is such as to corroborate that idea. Cunobeline, who was the sovereign of the Cassii and Trinobantes, erected mints at Camulodunum (Colchester),† Verulam, and London; and before the reduction of Britain, which occurred during the reign of his son, Carac-

* Vol. XIV. 105.

† Dio. p. 947. See also Pegge's Coins of Cunobeline.

tacus, his example had been followed by the Iceni, the Atrebates, the Segontiaci, the Durotriges, and the Brigantes. The latter had mints at Eburac, (York,) and at Isu, (Aldborough.)*

Such being the state of the coinage amongst the Britons, before the permanent establishment of the Roman dominion, it is natural to suppose that the latter people would avail themselves of the facilities already provided: and, accordingly, we find that of eleven mints, at the least, which they established, four or five were fixed in stations previously occupied by the Britons.

To return to the Coin-Moulds.—The principal instances of their occurrence are the following. The first notice we have of them is in the "Nummi Pembrokiani," where is a drawing of one bearing a head of Julia the wife of Severus. The locality from which these were procured is not mentioned. The late Lord Winchilsea had also several impressions which differed from those before us in being joined together on one flat piece of clay: the locality of these also is not known.† The first authenticated discovery in this kingdom was at Lingwell-Gate in 1697. They were again found there by our townsman Thoresby, about the year 1706.‡ The Coins for which these were intended were Severus, Julia his wife, Caracalla his son, Alexander Severus, his mother Mammæa, and Diadumenianus. About the

* Stukely and Camden. See Whitaker's History of Manchester, Vol. II. p. 6.

† Mr. Baker in Phil. Trans., Vol. XLVIII.

‡ Phil. Tr., Vol. XXIV.

same period great numbers were found at Lyons in France, and chiefly in that part of the city which was inhabited by the Romans, and which still retains the name Fourviére, probably from the Latin *Forum Vetus*.* The whole of these were of Severus, Julia Pia, and Caracalla. Others were found near the same time at Edington,† in Somersetshire, and at the latter end of the last century at Ryton, in Shropshire,‡ (probably the Rutunium of the Romans;) and again at Edington, in 1800.‖ The moulds at Ryton were of Severus, Julia, and Caracalla: those at Edington were of the same; and also of Geta, Macrinus, Elagabalus, Alexander Severus, Maximin, Maximus, Plautilla, Julia Paula, and Julia Mammæa.

But the largest deposit which has yet been known was turned up by the plough at Lingwell-Gate in 1830. The circumstance having attracted the attention of some gentlemen at Wakefield, a further search was instituted, and four crucibles were found, along with several funnels used in the process of casting. The whole of these were formed of a bluish white clay, which was very plentiful on the spot, about eighteen inches from the surface. It is worthy of remark that the colour of the soil is quite changed for some distance round, and as the ground is at present ploughed out, the extent of this change is very well defined. It is about ten yards in diameter;

* Mem. de l'Academie des Inscriptions, Vol. II.
† Gough's Camden, Vol. I. p. 71.
‡ Mr. Baker in Ph. Tr.
‖ Archæologia, Vol. XIV. p. 99.

and within this space the soil consists almost entirely of decomposed vegetable matter, with pieces of wood, of various sizes, scattered amongst it; which renders it probable that there has been a forge erected here, in the midst of the forest, and that the surrounding wood has been cut down to afford fuel, as well as space, for the operations of the coiners.

The moulds are of the coinages of Commodus, Severus, Julia, Geta, Caracalla (who assumed the name of Antoninus Pius,) Macrinus, and Alexander Severus.

It cannot but strike us, that, in all the cases cited above, the impressions have reference to a very limited period—namely, subsequent to the arrival of Severus in Britain. After the defeat of Albinus, Severus remained some time at Lyons, and his son Caracalla was born there. It is probable that this would give occasion to new coinages, which, as Lyons was one of the stations provided with a mint, would be uttered in the usual mode. The counterfeits would, for obvious reasons, be confined to the coin which was most current. Accordingly we learn from Mahudel that those found at Lyons consisted entirely of the heads of Severus, Julia, and Caracalla. After a time, the counterfeitors passing over into Britain along with Severus, continued to imitate the coinages above mentioned, which occur in immediate and direct succession, from the time of Severus to the departure of the Romans.

The single exception of Commodus, which occurs at Lingwell, does not invalidate, but rather strengthens this argument; for it is easy to conceive

how a few of his coins might be in circulation, whilst the circumstance of the great bulk of the moulds being of Severus, and his successors, tends to prove that there had been a regular succession of legal coinages. If it had not been so, the "pieces" cast from "necessity" must, *of necessity*, have been entirely of Emperors and Generals *anterior* to the time of Severus.

It is clear that the moulds in question have been made after, or during, the command of Maximus, who was sent by the senate against Maximin; for his is the last name which occurs amongst them.

But Severus had a mint in full operation at York, as well as at Chester; and coins from each of these, bearing his name, or that of his son Geta, have descended to our own times.*

The position of Lingwell, between these two mints of York and Chester, is a sufficient guarantee that there was no "necessity" for the casting in the present instance. But I may perhaps be allowed to offer a few remarks upon its situation, which I hope will at least be locally interesting.

Lingwell has been called a Roman station: its supposed etymology (Lingonum Vallum) implying that it was occupied by a cohort of the Lingones. It was thought to lie upon the route from Cambodunum to Calcaria (Tadcaster). If, however, we are

* Some of these coins bear the following inscriptions :—

"Col. Eboracum Leg. VI. Victrix."

See Camden, Vol. III. p. 9.

"Col. Divana Leg. XX. Victrix."

"Sept. Geta." Do. Vol. II. p. 423.

to look for Cambodunum at Slack, near Greetland, which is the generally received opinion, that route is still to be ascertained; and Lingwell would, at all events, be thrown out of the line. I think it likely that it has passed over the site of this town (Leeds,) where was a station described by Thoresby; and its direction is indicated by "the street" at Gildersome, and Adwalton, as well as in other parts of the line. This direction also corresponds with that of the second Iter of Antonine.

The remains of a Roman way are described by Mr. Watson, the Historian of Halifax, as pointing from Slack towards Legeolium (Castleford, near Pontefract).* On tracing this, we come to a considerable fortification at Kirklees, first noticed by the late Mr. Richardson of Bierley, in a letter to Mr. Hearne of Oxford.† Leaving Kirklees, "the street" is again found at Dewsbury and Ossett, and from thence appears to pass, as is usual with Roman roads, *along the ridge of the hill*, about a mile south of Lingwell‡ towards Castleford. Mr. Whitaker§ supposes the camp at Kirklees to be an intermediate station, occupied by a centurion's guard. He thinks it probable that there were generally one or more of these, between the principal stations, for the purpose of keeping up the communication between them, and to serve as resting places on a long march. Such he

* History of Halifax, p. 39.

† See Hearne's 2nd edit. of Leland's Itinerary, Vol. I. p. 146.

‡ It is observable that the Ryton coins were found at about a mile from the "Watling Street." The Edington coins also were found at a similar distance from what Aubrey considers a station of the Romans, and from the ruins of which Bridgewater was built.—Camden, Vol. I. p. 71.

§ History of Manchester, Vol. I. p. 233. 2nd edit.

believes to be the one at Castleshaw in Saddleworth, which would be between Mancunium and Cambodunum; and such also might be the one at Leeds, which would be midway between Cumbodunum and Calcaria. It is possible that there may have been a camp of this kind near Lingwell; for instance, at or near Alverthorpe, which lies upon the route above described, and where coins and other remains have not unfrequently been found. The distance between Cambodunum and Legeolium would thus be divided into three equal parts. It is very improbable, however, that an authorised coinage should have taken place in such an insignificant station; whilst on the other hand, it is not difficult to believe that the soldiers in such a place might seek the concealment of the neighbouring forest, for their illegal purposes. The peculiar character of the ground is favourable to this notion. At a distance from the evident line of road, in a hollow surrounded on every side by hills, in the heart of a forest, and on the banks of a stream which never fails, the forgers appear to have cut down the wood, and to have formed a retreat admirably calculated to escape observation, whilst these very circumstances render the spot less likely to be chosen by the Romans for a place of defence. Such a selection would be contrary to all we know of their habits.

If, then, we connect the foregoing observations with those which have been already advanced by others, the argument at present appears to stand thus. —It has been shown

That the Romans universally *struck* their coin, and that there is no historical notice of legal coining in any other mode:

That the greatest safeguard possible was provided against counterfeits by the strictness of the laws, and the rank and responsibility of the mint-masters:*

That for colonial coinage provision was made by the appointment of superintending officers, and the transmission of portable dies:

That, in Britain, every facility for this purpose was already prepared by the previous introduction of the art: And,

That the date of the Coin-Moulds proves their manufacture to have taken place at a period when the Roman armies were no longer dependent on their portable implements, inasmuch as permanent mints had been, for at least forty years, established within a very short distance.

In the particular instance which has called forth these remarks, it appears, further, that the situation of Lingwell, with respect to the Roman roads in this part of Yorkshire, renders it improbable that it ever was a station occupied by the Romans, or that there was any station near it, of sufficient importance to warrant the supposition that a coinage like the present could be put forth by authority.

After all, the notion of a forgery is far the

* It is supposed that the Triumviri were one for each of the legitimate metals, "Auro, argento, ære flando, feriundo."—Baldwin de Leg. Const. II. 614.

most natural one, and Pliny tells us that in his time "it was practised with so much art, that it became a particular science to distinguish a piece coined at the mint, from one cast in a sand-mould; and the imitations were so well executed, that the curious would often give many pieces of good money for one false one."

ON THE

ANATOMY OF ACTINIA CORIACEA;

BY THOMAS PRIDGIN TEALE:

READ DECEMBER 5th, 1834.

Actinia Coriacea.—Cuvier, Spix, Rapp.
Actinia Senilis ?—Linn:
Actinie Ridée ?—Lam:

THROUGHOUT the writings of Dicquémare, Reaumur, Cuvier, Spix, Rapp, and others, are scattered numerous observations on the structure of Actiniæ; but these anatomical notices are, for the most part, brief and general; and, when more elaborate, they are usually limited to some particular organ, and in many instances are obviously incorrect.

Under these circumstances, it has appeared to me desirable that some species of this extensive and interesting genus should be made the subject of special investigation; and in the hope of contributing, however imperfectly, to this end, I have undertaken the enquiry, and beg leave to submit to the Society the result of my observations.

The species selected for this purpose appears to be identical with the Actinia Coriacea of Cuvier, Spix, and Rapp, and probably with the Actinia Senilis of Linnæus, and the Actinie Ridée of Lamarck.

It is of rather frequent occurrence on the Yorkshire coast, being found in considerable numbers on the lias and oolite rocks of Redcar, Scarborough, and Filey, and more sparingly on the chalk at Flamborough. It is exposed at low tides, and its favourite locality is the bases of rocks, near the sand, in which it is often partially imbedded.

The external envelope is a dense coraceous membrane, closely studded with small tubercular elevations, arranged somewhat irregularly, but with a tendency towards vertical and transverse lines. To these eminences fragments of rocks and shells often adhere. The base, by which it attaches itself with great firmness to rocks, is one inch and a half in diameter, circular, and free from the tubercular eminences; the body is one inch and a half in height, subcylindrical, tubercular, terminating superiorly in a thick rounded margin or lip, which admits of being extensively expanded, or can contract so as completely to conceal the superior surface or roof, and the tentacula. The roof, bounded externally by the lip, supports a double or triple series of from one hundred and fifty to two hundred tentacula, half an inch in length when protruded, about half that size when retracted, conical, and tapering gradually from the base to the summit, which is slightly obtuse and perforated. Internally, to the tentacula, the roof presents a flattened surface, having a central aperture, the mouth, which communicates with a large internal cavity, the stomach.*

The colour of the body is most frequently

* Plate 9, figs. 1 and 2.

deep olive green, occasionally passing into yellow, orange, brown, and red, frequently, but not invariably, marked with irregular streaks and patches of bright red.

The tentacula are generally of the same colour as the body, but of a lighter shade, presenting, in most individuals, a circular band, near the middle, of a rather deeper tint of the same colour, or sometimes of red.

CUTANEOUS SYSTEM.

The external envelope consists of a corium and epidermis.

The corium constitutes the chief organ of support, giving to the animal its peculiar form. A circular horizontal portion forms the base or foot; a cylindrical vertical portion constitutes the sides, and is inflected at the superior border, so as to form a thick rounded lip. The corium is afterwards prolonged over the tentacula, giving investment and form to these organs, and is then extended horizontally to form the roof, near the centre of which it again becomes folded upon itself, forming an internal lip or mouth, at which part it is continuous with the digestive sac.*

The corium at the base and sides is one fiftieth of an inch in thickness, but is considerably thinner at the tentacula. On examining a thin section of corium by the lens, it appears a simple homogeneous translucent structure. Externally the corium, more particularly when deprived of epidermis, pre-

* Plate 10, fig. 1.

sents numerous tubercular eminences, of a conical form, disposed, as has been already stated, somewhat irregularly, but with a tendency to vertical and horizontal lines. These eminences are translucent at their circumference, and present at their summit a perforation which appears as an opaque multangular spot.* They admit of retraction to such a degree as to render the corium perfectly smooth, so that the small opaque spot alone indicates their former situation; they also can be protruded to nearly a line in length, when they bear a close resemblance to rudimentary tentacula. The eminences on one side are often seen in the utmost degree of protrusion, whilst, on the other, they are scarcely perceptible. If, in the protruded state, they be touched with the finger, they are immediately retracted, in the same manner as the tentacula are withdrawn under similar treatment. To these eminences fragments of sand and shell frequently adhere, and the resemblance which they bear to tentacula would lead to the suspicion that it is by a power of suction, similar to that which is exerted by the tentacula, that these foreign substances are retained; the great firmness of the adhesion, however, and its continuance, in some instances, after death,† somewhat militates against this idea, and suggests the possibility that the eminences are follicular glands, whose secretion agglutinates these substances to the integument. The internal surface gives attachment

* Plate 9, fig. 3.

† I have a specimen preserved in spirit, in which the foreign substances adhere to the skin with great tenacity.

to numerous muscles. On making a vertical section of the entire animal, the continuity of the corium with the stomach may be distinctly seen,* in which respect the skin of Actinia is strictly analogous to the cutaneous envelope of the higher classes of animals, in being continuous with the mucous membrane. The apparent contractility of the corium most probably depends upon the muscular fibres which are intimately connected with its internal surface.

The epidermis forms a thin layer of unorganised matter spread over the whole extent of the corium, and may be traced into the stomach. The external surface of the epidermis is dense and membranous; internally, when examined by the lens, it appears as a pulpy substance. Intimately intermixed with it, in irregular patches, and not constituting a distinct or separate layer, is a pigment varying in colour in different parts of the same animal, and in different individuals. This colouring matter is extensively distributed over the base, sides, tentacula, and roof, but I have never observed any trace of it in the stomach.

MUSCULAR SYSTEM.

In Actiniæ the muscular system exists in a high degree of development. The filaments of which it is composed are often distinctly fasciculated, and the fasciculi are grouped into masses or layers often constituting muscles of considerable extent and power. These muscles may be most conveniently described

* Plate 10, fig. 1.

by referring them to the different regions in which they occur.

*Muscles of the vertical Leaflets.**—The space between the cylindrical or lateral portion of skin and the stomach, is intersected into a vast number of vertical compartments, by certain membranous partitions, or leaflets, attached externally to the cylindrical portion of corium, internally extending towards the stomach and giving attachment to the ovaries, superiorly connected with the roof, and inferiorly with the base. These leaflets are generally of a quadrilateral form, the inferior edge being extensively attached to the base, and in many instances prolonged from the circumference to the centre, which forms a common point of union for numerous leaflets, whence their inferior borders seem to radiate. The internal border of most of the leaflets gives attachment to the ovaries and vermiform filaments, with the exception of a small portion of the upper part, which in many instances is attached to the stomach, and fixes it in its situation; a few of the leaflets, destitute of ovaries, are prolonged as far as the stomach, and are attached to this organ throughout the whole extent of their inner border. The breadth of the leaflets varies considerably, some extending scarcely a line from their external attachment, others reaching as far as the stomach, being nearly half an inch in breadth. The height generally corresponds with the height of the animal; a few, however, of the narrowest leaflets extending upwards from the base, terminate obliquely in the sides,

* Plate 10, figs. 3, 4, 5, and 6; and Plate 11, fig. 1.

without being prolonged as high as to the lip or roof.

Each leaflet consists of one or more distinct layers of muscle, and a delicate investing membrane. The muscular filaments are grouped in somewhat coarse fasciculi, particularly those which have a vertical direction, and they are often arranged in distinct layers. The direction of the fibres is extremely various; most of the larger fasciculi passing from the base in either a vertical direction to the roof, tentacula, and lip, or with a slight degree of obliquity into the sides; others pass with greater obliquity upwards and outwards, a few upwards and inwards, traversing the leaflets in a direction from the sides obliquely towards the roof and mouth. In addition to these vertical and oblique fibres, a transverse order of muscular filaments is observed, more delicately fasciculated than the former, extending across the leaflets, in a transverse direction, from the sides towards the bases of the tentacula, mouth, and stomach; the transverse fibres are more obvious at the upper than at the lower portion of the leaflet. Some leaflets present two, three, or more distinct perpendicular muscles, as well as oblique and transverse fibres; a few appear to consist of a single vertical muscle.

*Muscles of the Base.**—Those fibres of the leaflets, which have an attachment to the base, may, to a certain extent, be regarded of muscles of this part; besides these, however, there are special muscles of the base, arranged in a radiating and in

* Plate 10, fig. 8.

a circular direction. These are observed by separating and turning aside two of the leaflets so as to expose the narrow portion of the base which is situated between the attachment of their inferior borders. After carefully removing, with a camel's hair pencil and water, the mucous which obscures this part, two slender muscles, each composed of a single fasciculus of fibres, may be seen with the aid of a lens, extending from the centre to the circumference, close to the insertion of the inferior border of each leaflet. Between these two slender radiating muscles, are seen very delicate fibres, not fasciculated, crossing the intervening space, and constituting a portion of a circular order of muscles of the base.

*Muscles of the Sides.**—In addition to the fibres of the leaflets inserted into the sides, are also special muscles of this part. On turning aside two of the leaflets so as to expose the narrow portion of corium between the insertions of their outer borders, and cleansing it from mucous, distinct transverse bands of fibres may be seen crossing this narrow space and constituting part of a circular order of muscles of the sides.

Muscles of the Lip.†—The lip is a complicated structure, externally composed of the common integument, which doubled upon itself forms a rounded edge or border, within which are muscular fibres, prolonged upwards from the vertical leaflets; these fibres taking the course of the skin are, along with it, reflected, and thereby enclose a thick circular muscle, coarsely fasciculated, between the fasciculi

* Plate 10, fig. 7. † Plate 10, fig. 11.

of which are numerous cavities communicating freely below with the interseptal spaces; these cavities communicate above with numerous tubular eminences, arranged along the border of the lip, each of which is perforated at the summit, and resembles a rudimentary tentaculum. The summits of these eminences are generally white, and form a circle of glistening spots.

This structure allows water to pass freely from the interseptal spaces into the cavities within the lip, and thence into the tubular eminences, by which all these parts become forcibly injected and distended during the expansion of the animal. Contraction and closure of the lip is principally produced by the powerful action of the circular muscle, and is facilitated by the escape of the fluid from the apertures in the tubular eminences.

*Muscles of the Tentacula.**—The tentacula are formed of tubular prolongations of integument enclosing longitudinal and circular fibres. They are perforated at the summit, communicate freely at their base with the interseptal spaces, and are lined by a prolongation of the delicate investing membrane of the interseptal spaces. The perpendicular fibres are arranged in distinct and rather widely separated fasciculi, and are easily seen to be prolongations of the vertical fibres of the leaflets; the circular order of fibres are placed internally to the former, are not fasciculated, and form an extremely delicate layer; they are distinctly seen to be a plane of fibres continuous with the transverse fibres of the leaflets.

* Plate 10, figs. 9 and 10.

Near the summit of the tentacula the circular fibres become a little more developed, and constitute a kind of sphincter.

The structure and connections of the tentacula allow them to be readily distended with water from the interseptal spaces, by which they are protruded during the expansion of the animal; the escape of the water from the summits of the tentacula, and from the stomach, aided by the contraction of the longitudinal and circular fibres of the tentacula, produces the retraction of these organs.

Muscles of the Roof and Mouth.—The common integument, after having formed by its duplicature the lip, and by its tubular prolongations the tentacula, is extended in an horizontal direction as the roof, and becomes doubled upon itself, forming an inner lip or mouth, a circular aperture, at which part the external envelope becomes continuous with the stomach. Beneath the portion of integument forming the roof are numerous converging fibres, passing from the circumference towards the centre. These are evidently the transverse fibres of the upper part of the leaflets continued along the roof to the mouth, where some of them turn downwards to constitute a muscular coat of the stomach.

In addition to these converging fibres, a circular layer surrounds the mouth, in which part are numerous cavities communicating with the interseptal spaces, and admitting of distension by water injected from these spaces.

Muscles of the Stomach.—These fibres will be noticed in treating of the digestive apparatus.

DIGESTIVE SYSTEM.

The stomach is a membranous cavity formed by an internal prolongation of the common integument.

It is bounded above by the mouth, below it forms an imperfect sac, terminating abruptly, and leaving a circular portion* near the central part of the base deficient, where it communicates freely with the interseptal spaces, and where portions of the vermiform filaments, and sometimes of the ovaries, are seen protruding into the stomach. Spix describes and represents numerous very minute apertures at the inferior part of the stomach as the terminations of the oviducts. These apertures I have not been able to detect.

The stomach is principally composed of the corium, which here constitutes a mucous membrane, lined by epidermis, but destitute of colouring matter. It is strengthened by a series of muscular fibres passing downwards from the mouth to its inferior boundary. These fibres are an evident prolongation of the converging fibres of the roof, which after having traversed the roof and reached the edge of the mouth, suddenly turn downwards to give an investment to the stomach. Lamarck has noticed "flat longitudinal parallel fibres surrounding the alimentary sac."†

The stomach is held in its situation by numerous fibres of a tendinous or perhaps muscular cha-

* Plate 10, fig. 2, *a*.

† Lamarck, Hist: Nat: des Animaux sans vertibres, 3, 65.

racter, which pass from the internal border of the vertical leaflets to the sides of this organ. The attachments are most numerous to the upper portions of the leaflets above the part where the ovaries are attached. To some of the leaflets, which are destitute of ovaries, the stomach is connected nearly throughout their whole extent. These connections with the leaflets produce a plicated appearance of the internal surface of the stomach, throwing this membrane into numerous minute vertical folds. Two of these folds, placed opposite to each other, are much broader and more strongly marked than the rest.* They are produced on each side by the firm adherence of the gastric membrane to a pair of very dense, fleshy, but narrow leaflets, throughout their whole extent, or, in other words, from the top to the bottom of their internal border. These depressions divide the animal into two lateral halves, constituting a bilateral symmetry in Actinia, as has been observed by M. Agassiz in other supposed radiated animals.

The stomach, with its circular aperture at the base, and its two depressed folds, may be most conveniently observed on the spontaneous eversion of the animal. If several specimens be placed for a few hours in a basin of sea-water, some of them will begin to protrude the small folds of the stomach, and this protrusion proceeds until the whole of the stomach is everted; in this state specimens may be preserved by suddenly immersing them in spirit. This spontaneous eversion I have frequently seen

* Plate 10, fig. 2, *b. c.*

in Actinia Coriacea, but never in Actinia Equina (Actinia Purpurea, Cuv:)

In the stomach is poured out a very copious and viscid secretion, which appears to be the principal agent in the digestive process.

Actiniæ are remarkably voracious, and devour large animals, often of higher grades than themselves. In the stomach of an Actinia Equina I found a bivalve one inch in length, by which the animal was distended considerably beyond its natural size, and from an Actinia Coriacea I obtained portions of a crab broken into fragments, which must have been as large as itself. They greedily devour crustacea, shell-animals, and small fishes. Dicquémare observed that they would swallow individuals of their own genus; these, however, were not digested, but were rejected alive in eight, ten, or twelve hours. Although often so voracious, Dicquémare ascertained that they could exist more than a year without any other food than the animalcules existing in sea-water. The ordinary period of digestion appears to occupy forty, fifty, or sixty hours. M. Dicquémare found that when living bivalves were swallowed, their shells were ejected in the time above mentioned.

An interesting enquiry here presents itself. By what means is the nutrient fluid resulting from the digestive process conveyed from the stomach into the different textures of the animal for the purposes of growth and nutrition? In the Echinoderma, animals a little more elevated in the scale of organization than Actiniæ, the nutrient fluid is distributed

by distinct blood vessels, but as yet no isolated system of vessels of this character has been detected in Actiniæ. In the Medusariæ, ramified canals are seen extending from the stomach, by which the digested alimentary matters are conveyed to distant parts of the body, and it is not improbable that the numerous interseptal spaces of Actiniæ, which we may regard as cavities prolonged from the stomach, answer a similar purpose of diffusing the nutrient fluid throughout their body, and of exposing it to an extensive membranous surface for absorption.

REPRODUCTIVE SYSTEM.

The Ovaries.—The ovaries, about two hundred in number, form elongated masses attached along the inner border of most of the leaflets.* Each ovary is composed of several horozontal folds or plaits, which, when unfolded,† show this structure to be about three times the length it assumes when attached to the leaflet. By carefully spreading out these folds, the ovary, with the assistance of a lens, is seen to consist of two very delicate layers of membrane, enveloping a closely compacted layer of ova. After enveloping the ova, the membranous layers are placed in apposition, and form a kind of mesentery,‡ by which the ovary is attached to the internal border of the leaflet. The two layers afterwards separate to pass one on each side of the leaflet, thereby lining the interseptal spaces, from which this membranous investment is prolonged into

* Plate 11, fig. 1, *e*. † Plate 11, fig. 2.
‡ Plate 11, fig. 1, *f*.

the tentacula, as well as into the cavities within the structure of the lip and mouth. At the summits of the tentacula, and of the tubular eminences of the lip, the membrane becomes continuous with the common integument, whilst at the inferior part of the interseptal spaces it is continuous with the digestive sac. The breadth of the ovaries is nearly uniform from the top to the bottom. Some irregularities are occasionally observed in their attachments to the leaflets. Sometimes one leaflet supports two ovaries, and not unfrequently two neighbouring ovaries are continuous with each other at their inferior extremities.

The Ova.—The ova are round, except in an advanced stage of development, when their circular outline becomes a little interrupted by the pressure of neighbouring ova. A well marked central depression may also then be seen indicating the situation of the oral aperture, but without tentacula. The ova, when of large size, project considerably beyond the surface of the ovary, protruding before them their delicate investing membrane. In this state they are readily detached by very slight pressure with the point of a needle.

The ova are nearly of the same size in the same ovary, except a few small ones scattered here and there amongst those which are generally more mature. There is no regular gradation of size in the ova from the top to the bottom of the ovary, as if they successively arrived at maturity in that order as imagined by M. Spix. In the same individual, however, are sometimes seen ovaries whose

ova are generally less developed than those of neighbouring ovaries. At the same season also it is common to find different individuals, even from the same rock, with their ova in very different stages of development; some exhibiting the ova distinctly to the naked eye, whilst others require the lens for their detection. This difference in the development of the ova in different individuals is not limited to any particular season. I have repeatedly observed it throughout the whole of Spring, Summer, and Autumn, from March to November inclusive.

The colour of the ova in this species varies considerably. It is most frequently pale yellow, but is occasionally white, pink, or brown.

*The Vermiform Filaments.**—Connected with each ovary is a remarkable structure, whose nature and offices are involved in considerable obscurity.

It appears as a delicate vermiform thread, minutely convoluted, and united by a mesentery to the inner border of the ovary. It is of a milk-white colour, about the thickness of a horse-hair, and of extremely soft consistency, yielding readily to slight pressure of a needle. By its numerous convolutions it constitutes a mass of an elongated form, attached superiorly to the inner border of the leaflet above the attachment of the ovary, it then passes over the ovary, united to the whole length of its inner border, and below the ovary it has an attachment to the inferior part of the internal border of the leaflet. Superiorly the filament is extremely minute, and in the multitude

* Plate 11, fig. 1, *g*.

of its convolutions I have been unable to detect its point of commencement, for, in attempting to unravel these convolutions with the needle, their delicate structure has been unavoidably lacerated. The difficulty of detecting its commencement is in many instances still further increased by two neighbouring convoluted masses being frequently continuous at their upper extremities. Inferiorly the filament becomes gradually increased in size and less convoluted, and at length it appears as a simple wavy line, still attached by its mesentery to the inferior part of the leaflet, near which it terminates in the coats of the stomach. The orifices by which the filament, if tubular, may open into the stomach, I have not been able to detect; they are, however, distinctly represented by M. Spix, in his plate of Actinia Coriacea. It is most probable, and indeed there can be but little doubt, that the filament is tubular; but of this I have not yet been able to obtain evidence. Under the microscope it appears simply as a round, solid, translucent chord.

The vermiform filament can only be seen to advantage in the living animal, and it may be readily observed protruding through the lacerations of the integument, which in most instances are produced by detaching the Actinia from the rock. If the filament be immersed in water for half an hour after vitality has ceased, its characteristic appearances become obscured or lost from the rapid endosmose which occurs in this tissue after death, but which it resists during life. In diluted alcohol this obscuration of the tissue takes place, but less rapidly than

in water. I have repeatedly placed portions of the vermiform filament in spirit for the purpose of preservation, but the natural appearances of it only remained for one or perhaps two days, after which it was impossible to recognise the structure, a mere flocculent membranous substance remaining. The only manner in which I have been able to preserve it has been by spreading small portions upon glass as objects for the microscope. When dried on the glass these specimens have retained much of their characteristic appearance, exhibiting distinctly the rounded filament and its mesentery.* A line of granular fatty matter is seen, in some specimens more distinctly than in others, accompanying the filament throughout its whole extent, and enclosed within the layers of the mesentery.

It is this filament which has been frequently noticed as protruding from the mouth and sides of Actinia. M. Dicquémare speaks of "soft limber threads, of the thickness of a horse hair," and Cuvier notices the long filaments proceeding from the ovaries, and protruding at the mouth.

For the purpose of examining this limber thread I placed several specimens of Actinia Coriacea and Actinia Plumosa in sea-water in the month of August. Some of them soon began to protrude long slender hair-like filaments, others ejected a small rounded white mass, which on examination was the same kind of filament, but with its mesentery attached, which caused it to retain the convoluted arrangement, and prevented it assuming the

* Plate 11, figs. 3 and 4.

elongated form. Other masses of larger size were also cast off, and these proved to be portions of ovary, with some of the white convoluted substance attached to them.

These hair-like filaments were observed to possess a distinct serpentine motion. Some of them, about an inch in length, were placed in sea-water upon the shell of a murex, where they slowly coiled themselves into a variety of forms, and possessed a considerable locomotive power, having traversed a great extent of the surface of the shell in a few hours; afterwards their motions gradually ceased, they remained fixed to one part of the shell, their form and outline became somewhat obscured from a surrounding cloudiness in which they were enveloped, and in twenty-four hours a diffused whitish flocculent substance was the only trace of them that remained. The same vermicular movements were observed in those portions to which the mesentery was adhering.

I am of opinion that these substances and filaments are not spontaneously protruded by the animal, but that they are cast off in consequence of having been detached by mechanical violence, as I have never been able to detect them protruding from Actiniæ whilst unmolested in their native haunts. When, however, they are separated from the rocks, (a process requiring considerable force,) and are placed in a basin of sea-water, these filaments, convoluted masses, and portions of ovaries, are protruded in considerable abundance.

The preceding description of the ovaries and

vermiform filaments differs materially from that of the ovaries given by M. Spix, and it would have been with the greatest diffidence that I advanced opinions at variance with those of so respectable an authority, more particularly as the descriptions which he has given, as well as his plates, have for many years been regarded as the standard of reference on the subject, and have been copied by Professors Carus and Goldfuss and other naturalists, had not the strongest conviction of the inaccuracy of M. Spix been forced upon my mind by repeated and careful dissections, the results of which, as far as regards the ovaries, may at any time be verified by reference to the preparations of these parts which I have preserved in spirit.

The following are the observations of M. Spix: "Chaque ovaire est composé de trois ou quatre boyaux cylindriques et cohérens, qui, vers la base, s'allongent dans un tuyau commun, et dont le sommet s'amincit en pointe, à mesure que les œufs deviennent plus petits (chaque ovaire en contient à peu prés un soixantaine.) Les tubes communs de deux ovaires des plus voisins se reunissent, en serpentant, dans un seul, au moment qu'ils sortent de la concavité longitudinale; ce dernier forme ensuite, avec le canal du paire prochaine l'oviducte, qui est consequemment commun aux quatre ovaires, et s'ouvre dans l'estomac. L'insertion s'y fait en zigzag; car les uns entrent plus haut, et les autres plus bas."*

In the above quotation it is evident that M.

* Annales du Muséum.

Spix has described as both ovary and oviduct what in the preceding pages has been spoken of as the vermiform filament, having either altogether overlooked the true ovary, or confounded it with the vermiform filament; for when he describes the ovary as composed of three or four cylindrical and coherent tubes (boyaux) which after performing a serpentine course, are prolonged inferiorly into a common tube, ultimately terminating in the stomach, it is obvious that the description can refer only to the vermiform filament, and that no part of it can belong to that flattened layer of ova, enveloped in two layers of membrane, which conjointly constitute the true ovary.

Much doubt exists as to the nature of the vermiform filament, and I have designedly selected for it a name which does not imply any opinion as to its function. The convoluted form of this filament, and its connection with the ovary, have probably suggested the idea that it is an oviduct; an opinion, however, which has but little evidence for its support, and not much probability in its favour. It is somewhat difficult to imagine how the fully developed ova, distending their envelope, and ready to burst through their slight membranous barrier, and fall into the interseptal spaces, should reach and obtain entrance into the commencement of this delicate tube; on the contrary it is much more easy to suppose that, when sufficiently matured, they actually burst their membranous envelope and become lodged in the interseptal spaces, where they are exposed to the free access and continued supplies

of sea-water, the grand stimulus to their further development. This supposition receives some confirmation from the fact that in the smaller species of Actinia (Actinia Equina) so abundant on our coasts, it is in the interseptal spaces, and not in the stomach, that the young are lodged; and in that situation, during the months of Spring, Summer, and Autumn, if not of Winter, they may be found of various sizes, from a small red point not larger than a pin's head, to that of fully developed Actiniæ two lines in diameter. When, also, we consider the immense length of all the vermiform filaments, which when taken conjointly, exceed by many hundred times that of the animal, and when we consider the immense number of ova, there being some thousands in each Actinia, it is reasonable to expect if these tubes were really oviducts, that occasionally ova, so numerous, might be detected traversing canals of such extraordinary length. To ascertain this point, I have examined many thousands of the tubes, in Actiniæ, whose ova were fully developed, but have never been able to detect a single ovum in its transit.

In the absence, then, if any direct evidence as to the nature of these tubes, I am inclined to suspect that they are elongated follicular glands, analogous to the salivary, pancreatic, and hepatic follicles of animals a little higher in the scale of organization, supplying secretions subservient to the digestive process.

RESPIRATORY SYSTEM.

The extensive internal membranous surface,

exposed to the free access of sea-water, with the addition of the external envelope, must be regarded as the respiratory apparatus. From the inferior aperture of the stomach, water has ready access to the numerous compartments of the interseptal spaces, and from these to the various cavities of the lip, tentacula, and mouth.*

NERVOUS SYSTEM.

From the highly developed state of the muscular system in Actinia, it might be imagined that the nervous system existed in a corresponding degree of development. Under this impression I have repeatedly searched for the nerves with the greatest

* In May last, at Scarborough, I detected the existence of ciliary currents along the surfaces of the muscular leaflets, without being aware at the time that Dr. Sharpey, as early as 1830, had observed these currents in Actiniæ. He has since pursued the investigation further, and in the recently published numbers of the Cyclopædia of Anatomy and Physiology, has described the various parts of Actiniæ on which the currents occur, as well as their particular directions. Dr. Sharpey has observed them on the surface of the oviducts, (in the present paper described as the vermiform filaments,) and their supporting membrane, and also on the internal surface of the stomach. "In one small but full-grown species," Dr. Sharpey further observes, "I found currents commencing near the centre of the disc, and proceeding outwards in a radiating manner to its circumference, whence they continued along the arms as far as the points. On examining this species, which was semi-transparent, by transmitted light, I distinctly perceived moving particles in the water contained within the tentacula, and behind the protruded stomach. Some of these particles were no doubt ova. The motion of these particles obviously indicated a current in the water along the surfaces containing it, which current, like that on the oviducts, it may be inferred was produced by cilia, for it went on while there was no perceptible contraction taking place in any part of the animal. The particles indicating the currents within the tentacula, were moved in two different directions, namely, from the base to the point, and from the point to the base, and (supposing the arm spread out horizontally) the outward current was along the under part of the tube and the returning one along the upper."—*August* 30, 1836.

care, but as my investigation has been hitherto unattended with success, I will here take the liberty of quoting the observations of M. Spix, "Ayant soulevé par une legere incision, les muscles longitudinaux à leur reunion au milieu de la base, j'aperçus, par une loupe, un entrelacement formé de quelques paires de nodules, disposés autour de centre, et qui communiquent par plusieurs filets cylindriques. De chaque nodule, deux filets se dérigent en avant ; on voit l'un ramper le long du muscle, l'autre le percer, se diviser en deux branches, et enfin se perdre dans la cavité longitudinale que forme les muscles flottans. La situation des nodules et des filets au-dessous de l'estomac, et leur figure ronde ne me laissérent pas les confondre avec les muscles, qui sont larges et aplatis, en forme de rubans, d'autant moins, que je vis les derniers pourrir trés-promptement, tandis que les premiers restèrent intacts."—p. 444.

Whilst I am compelled to acknowledge my want of success in detecting the nervous system of Actinia, it affords me some consolation to find the distinguished M. de Blainville in a similar dilemma. In allusion to the description of M. Spix, he remarks,* "J'avoue que, quelques soins que j'aie mit à le chercher où il l'indique sur des individus d'une grande taille, tout frais et même vivans, il m'a été absolument impossible de rien rencontrer de semblable à ce qu'il a decrit et même figuré." M. Blainville further remarks that he has observed in the substance of the inner lip, or mouth, a grey pulpy chord, which he has thought might probably be

* Manuel d' Actinologie et de Zoophytologie, p. 80.

nervous. I have frequently seen a similar filament in this situation, which from its extreme softness, and from its being connected with rigidly contracted muscles, immediately disappeared or became lacerated when an attempt was made to separate the muscular leaflets, or to trace it with the dissecting needle. This, however, is a much more probable situation for the nervous system than that assigned to it by M. Spix.

ON

ALCYONELLA STAGNORUM;

BY THOMAS PRIDGIN TEALE:

READ NOVEMBER 13th, 1835.

Alcyonella Stagnorum.—Lamarck, ii. 100.
Alcyonium Fluviatile.—Bruguiére, Encycl: Meth:
Alcyonelle Fluviatile. { Raspail, Mem: de la Société d'Histoire Naturelle, 1828.

On the tenth of August, in the present year, Mr. George Matthewman presented me with a large zoophytic mass taken from a pond in his father's garden, at Little Woodhouse, near Leeds, which on examination was found to consist of a horny basis, arranged in tubes, for the most part of a pentagonal form, opening on the surface by pentagonal apertures, and containing a gelatinous substance. When placed in water, it soon exhibited a multitude of polypes projecting from the tubes, each polype consisting of a beautiful expansion of about fifty tentacula, arranged in a complete circle, indented on one side so as to produce the appearance of a double row of tentacula arranged in a horse-shoe form.

Not being aware of any polype whose characters agreed with those just described, I referred for

information to the works of Natural History within my reach, and the only Zoophyte, to which I could suppose that it approximated, was Alcyonella, of which Lamarck* states that the polypiferous mass is composed of subpentagonal tubes, and that the polypes consist of fifteen to twenty straight tentacula arranged around the mouth in a circle incomplete on one side. He further states that he only knows of one species of the genus, and that it had been described and figured by Bruguiére in the Encyclopédie Methodique. On reference to the plate alluded to I found the tentacula represented as being terminated by a rounded head or button.

As it is stated by Lamarck that he had had the opportunity of examining the living animal from the pond of Plessis-Piquet, near Paris, I could not have the least doubt of the accuracy of his description, and consequently arrived at the conclusion that the animal now under consideration was not the Alcyonella, for although it corresponded with the latter in the description of the horny basis, yet the small number of tentacula, the rounded head at their extremities, and the incomplete circle which they formed, constituted characters so strikingly different from the subject of the present enquiry, that I felt convinced that it must belong to a genus not yet described, and that in undertaking the investigation

* "Polypier fixé, encrontant; a masse convexe and irreguliére; constitué par une seule sorte de substance; et composé de l'aggregation de tubes verticaux, subpentagonés; ouverts a leur sommet. Polypes a corps allongée, cylindrique, offrants a leur extremeté superieure quinze a vingt tentacules droits, disposée autour de la bouche en un cercle incomplet d'un coté.—Lam: ii. 100, 1836.

of its structure and habits, I should be engaged in a pursuit not unacceptable to the Society, and might probably be enabled to make some small contribution to natural history.

After my investigations had terminated, I received from Paris the volume of the Memoires de la Société d'Histoire Naturelle for 1828, containing the essay of M. Raspail on Alcyonella, and was not a little surprised to find that the descriptions of Bruguiére and Lamarck were quite incorrect, and that the Alcyonella, instead of having from fifteen to twenty straight tentacula terminated by a rounded head, had really not less than forty-four tentacula perfectly linear; and that the tentacula, instead of forming an incomplete circle, were arranged in a complete unbroken series depressed on one side.

It is scarcely necessary for me to say that my own observations had, in many of the most essential points, been anticipated, and that in several instances the investigations of M. Raspail had been pursued to an extent which my own inexperience in such enquiries, and my imperfect means of observation had not allowed me to reach.

After the elaborate essay of M. Raspail, it might appear a work of supererogation in me to proceed with the subject; but as the essay alluded to, although published in 1828, has not, as far as I am aware, been noticed by the British press, and as the Alcyonella has not been recorded as a British animal, I feel justified in proceeding, and shall give the description of it in the manner I had arranged previously to seeing this memoir, and shall conclude

with a brief sketch of the bold and ingenious generalizations adopted by M. Raspail, in reference to Alcyonella and several neighbouring genera.

HABITAT.

The pond from which the specimen was obtained, was originally one of those excavations in a bed of clay popularly known in this district as a "brick-pond," but now constitutes a pleasing ornament of an enclosure of moderate extent, tastefully laid out as gardens. The pond is abundantly stocked with carp and gold-fish, which here attain a considerable size. It is about twenty-five yards in length, and half as much in breadth. The depth towards the northern extremity is five or six feet, but towards the South the water becomes gradually shallower, so that the mud and weeds at the bottom can be seen to a considerable distance. The water, which is never stagnant, is derived from drains from the more elevated fields in the vicinity, and also from a spring in the basin of the pond. It contains evident traces of iron, and a spring in the adjoining field is so strongly impregnated with iron as to give a ferruginous tinge to the substances over which it passes, and on this account has long been known as the "Cankerwell." The northern extremity of the pond is sheltered by a fence of willows whose drooping branches are deeply pendent in the water, and frequently form a basis for the deposit and growth of Alcyonellæ.

On visiting the pond on the 11th of August, I found the Alcyonellæ in great abundance. At the

shallower part of the pond they occurred as irregularly rounded masses, and were with difficulty distinguishable from the mud and weeds by which they were surrounded. On viewing these masses externally they appeared as isolated and independent structures, without conveying the idea of their being incrustations deposited upon other substances, but on making a section of them, each exhibited a nucleus of some foreign material, generally a small twig, which it had originally incrusted, and from which during its progressive growth it had radiated as from a centre. Other Alcyonellæ were observed of large size, encircling or incrusting substances at the bottom of the pond. Dead twigs fixed in the mud, and projecting upwards into the water, presented circular masses of large size. An old glass garden-shade, which had been some time in the water, was loaded with lobulated incrustations. A large piece of earthenware was similarly incrusted, and fragments of sand-stone, on their lateral and superior surfaces, were the seat of Alcyonellæ. The slender twigs of willow which were pendent in the water were in some instances weighed down by the load of Alcyonellæ surrounding them; some twigs presented but a thin layer of the animal, and some leaves were seen with but a few tubuli ramifying on their surface.

At this visit, all the specimens which were easily accessible were removed, but in a few days the Alcyonellæ were again found as large and as numerous as before. During the months of August and September they were frequently removed, and

in a very short time their places were supplied with fresh Alcyonellæ. In the middle of October they were remarkably abundant, but on the 9th of November scarcely any were to be found; at which date the old garden-glass was the only source whence they could be obtained, and the greater number of these were dead black, and putrid, and a few exhibited very faint evidences of vitality.

The appearance of Alcyonellæ in this situation during last Summer is remarkable, as it is not probable that they could have existed there in previous seasons; for during many summers the fish and the various aquatic animals have been a constant source of amusement and observation to the owners, and if the large masses of Alcyonellæ had existed, it is scarcely to be supposed that they would have escaped observation. For the same reason it is probable that they had not existed in the present year in any considerable quantity at a date much earlier than that above mentioned. Their equally sudden disappearance may also be anticipated, for Bruguiére, although during one season he had many opportunities of examining Alcyonellæ from the pond of Bagnolet, was never afterwards able to pursue his observations, as they were never again to be found at Bagnolet.*

* During the whole of the Spring and Summer of 1836 repeated searches were made for the Alcyonellæ in Mr. Matthewman's pond, but without success, until the 1st of August, when a few small specimens were found attached to the living pendent twigs of willow and to the old garden-glass. On visiting the pond again at the beginning of September, I could not obtain any specimens whatever, except a few of small size from the garden-glass. The pond at Haigh-Park was visited on the 27th of July, when a few Alcyonellæ, forming thin incrustations upon dead twigs were found, and on the 3rd of September, after a very industrious search, only about

It was my intention during the Summer to have ascertained whether Alcyonellæ existed in other ponds in this neighbourhood, but the only one which I had the opportunity of examining was at the race-course in Haigh-Park, near Leeds, where, after two diligent searches, I procured five specimens of small size. These were found accompanying spongilla friablis, and encrusting dead twigs.

THE POLYPIFEROUS MASSES.

The polypiferous masses are round, sub-lobulated and botryoidal; incrusting stones, leaves, twigs, earthenware, and garden utensils, which had been accidentally deposited in the pond; the size varying from a thin incrustation to masses of several inches in circumference. One specimen, weighed seventeen ounces, and measured fourteen inches and a half in circumference. The surface presents numerous subpentagonal apertures, closed by a translucent polypiferous papilla, which on immersion in alcohol becomes opaque. The apertures on the surface, corresponding with the size of the tubes, are generally about one-fortieth of an inch in diameter; a few of smaller size indicate the commencement of new ramifications. A vertical section exhibits numerous tubes, radiating from a central nucleus, and in their course giving off lateral branches, which,

half a dozen small specimens could be obtained. Hence it appears that the present season is far less favourable for their production than last year; and from the close observation that has been kept at Mr. Matthewman's pond, it is obvious that their development did not take place until the Summer was far advanced, whereas Raspail speaks of the Spring as the time when the development of these polypes from their ova occurred in the neighbourhood of Paris.—*Sept. 5,* 1836.

being placed in apposition with the original tubes, increase the size of the mass as the tubes proceed from the centre. The colour, when the polypes are retracted, is a dirty sea-green, closely resembling that of the mud and weeds; during the full expansion of the polypes the surface of the mass has a paler aspect, and exhibits a velvety, or whitish downy appearance from the thousands of minute tentacula with which it is covered. The odour is peculiar, somewhat resembling that of stagnant water. The masses form a nidus for immense numbers of the larvæ of phryganeæ.

On combustion, the substance of the basis emits a smell like that from horn when burnt. The black ash which remains does not contain any particles which scratch glass. On treating the unburnt substance of the basis with acids, no effervescence takes place. From these rude attempts at analysis it may be inferred that the basis is composed of a horny matter, and that it does not contain spicula of silica or of carbonate of lime.

THE PAPILLA AND POLYPE.

Each tube is the seat of a distinct polype, which appears as a translucent conical papilla* when the tentacula are not expanded. The papilla admits of being completely withdrawn into the horny tube; more frequently, however, it is seen projecting a little from the surface, and is sometimes protruded to such a degree that its length is three times its breadth. The base of the papilla is attached to the

* Plate 12, fig. 1.

upper part of the horny tube, which is thereby perfectly closed. The apex presents a funnel-shaped aperture with striated sides, communicating with an internal cavity or canal, generally containing opaque matter. Some of the papillæ appear small or immature.

When a living specimen is placed in water under the microscope, the aperture at the apex of the papilla is soon observed gradually to widen; the papilla loses its conical form and assumes the appearance of a cylindrical collar,* from the interior of which is seen slowly protruding a beautiful expansion of tentacula, about fifty in number, arranged in an unbroken circle, which is, however, depressed into a deep concavity on one of its sides, so as to produce, as has been already noticed, the appearance of a double row of tentacnla in a horse-shoe form. About one thousand six hundred polypes are situated on a square inch of surface of the mass, consequently the number of polypes in the large specimen before alluded to, and placed in the Society's Museum, may be computed at one hundred and six thousand, and the tentacula at five millions three hundred and twenty thousand.

The tentacula, arising from the two sides of two slightly divergent fleshy arms, are linear and often slightly recurved at their free extremity. This recurved state of the extremity appears to have given rise to the error of Bruguiére respecting the button-like termination of the tentacula; an error which might easily be committed if the examination be

* Plate 12, fig. 2.

made with only moderate magnifying powers. If examined by a common pocket lens of one and a half inch, or even of three quarters of an inch focus, the tentacula appear to be terminated by a rounded knob. This, however, is merely an optical illusion from the recurved state of the extremities of the tentacula, and their linear form throughout becomes immediately obvious on examining them with higher powers. For this purpose, it is easy to detach an entire living polype, and to examine it, when expanded in a watch-glass, with a lens of one-tenth of an inch focus, and single tentacula may be separated and examined with a still higher magnifying power (one-thirtieth of an inch) when the appearance of vibratile cilia on their surfaces becomes distinct.

When an expanded polype is examined with a high magnifying power, a multitude of flocculent particles and animalcules are seen in rapid motion in its immediate neighbourhood. If these moving particles be attentively observed it is obvious that they are propelled by currents which have a definite course. These currents proceed along the outer edge of each tentaculum, wind round its apex, and descend along its internal surface to the mouth, whence some of the particles are again propelled from the centre of the crater. It is by these currents that food is conveyed to the mouth, and not by any prehensile motion in the tentacula themselves, for during the periods when the currents are most vigorous the tentacula are generally perfectly motionless. When an entire polype is extracted

from the horny tube and placed in a watch-glass under the microscope, so great is the force of the currents excited along the surface of its tentacula, that the entire polype is moved by them freely through the water, performing repeated gyrations, and exciting an appearance of incessant turmoil in the particles in the neighbourhood. If a single tentaculum be detached, it also is seen to move freely in the water by the currents excited along its own surfaces.

The animal has the power of instantaneously retracting the entire polype. This is observed on examining an extensive surface of expanded polypes, when one here and there will be occasionally seen to be retracted with the rapidity of lightning as if from alarm. Sometimes a more slow and gradual retraction of the polype takes place, which after a time is succeeded by a slow and gradual expansion. Occasionally a single tentaculum is seen violently to recoil itself into a complete circle; at other times one of these filaments will become violently bent inwards, and perform various contortions as if to get rid of an animalcule too large for deglutition, which has been hurried along the vortex into the crater of the tentacula.

DIGESTIVE APPARATUS.

The mouth* is a circular aperture situated at the bottom of the crater formed by the tentacula. It communicates below with an œsophagus, which soon becomes somewhat expanded, and constitutes

* Plate 12, fig. 2.

the stomach, the inferior portion of which is concealed within the horny tube. A second canal from time to time becomes obvious from the transit of opaque oval masses of excrement which are seen slowly ascending, and at length escaping from an aperture at its superior extremity. This orifice is placed externally to the crater, beneath the tentacula, and corresponds with the concavity formed by the divergence of the two fleshy arms which support the tentacula. The communication of these two canals is seen on separating some of the entire polypes from the horny tubes, and examining them in a watch-glass under the microscope, when the inferior part of the stomach is seen to turn suddenly upwards, and to be continuous with the intestine. The lower portion of the stomach is of a bright brown colour, longitudinally striated. The colour appears to depend upon the alimentary materials which it contains, and the vertical striæ are probably produced by folds in the organ. On lacerating the stomach the brown matter escapes in the form of innumerable minute granules. A sort of vermicular motion is sometimes observed in the stomach.

THE OVARIES AND OVA.

If a vertical section be made of one of the polypiferous masses, it is easy, with a fine instrument to detach the entire contents of some of the tubes. The substances thus detached consist of two parts: first, the polype and its papillary sheath,*

* Plate 12, fig. 3, *a* and *b*.

enclosing the alimentary canal, which occupies the upper part of the horny tubes: secondly, an elongated membranous tube, connected with the papilla above, and extending below throughout the horny tube.

This tube is the ovary,* and contains a series of compressed oval bodies, apparently floating or suspended in a fluid, by which the tube is distended. The ova appear in different states of maturity. Those which are perfectly matured are of a dark reddish brown colour. Others of the same size have their external envelope opaque and white; others are somewhat smaller and translucent, whilst some are very minute and perfectly transparent. The mature and immature ova appear scattered indiscriminately throughout the tube. The ova are stated by Raspail to occur in a double series, I have, however, almost invariably found them in a single row. M. Raspail also says he has been able to see the small filament which connects the ova to their containing membranous tube.

The mature ova have a dense horny envelope, which, on being burst, gives exit to a multitude of minute transparent granules.

The ova appear to float in a fluid in the ovary, and by pressure on different parts of the tube they may be made to pass backwards and forwards. On pushing the ova upwards in the tube, by means of a needle, they are arrested at the upper extremity of it, which is perfectly closed and does not allow of their escape into the polype, until an artificial rent or aperture is produced.

* Plate 12, fig. 3, *c*.

The mode by which the ova are disengaged is by a process of decomposition, and consists of two stages.

In the first, the papilla which during life closes the tubes dies and becomes softened, ragged, and flocculent, and in this state no longer forms a barrier to the exit of the ova. In November, many of the specimens were seen in this condition. On examining the surface of the polypiferous masses, they were seen covered with ragged shreds of membrane instead of the well-defined conical papillæ or expanded polypes.

In the second stage, air is disengaged from decomposition of the contents of the horny tube or ovary. If a recently dead specimen, in which the papillæ are reduced to the state above described, be examined with the lens, a succession of air-bubbles are seen frequently escaping from the horny tubes. By the successive formation and ascent of these bubbles the ova, which at this period are loose and floating in the tubes, are gradually elevated and conveyed to the exterior. In November, many of the specimens were seen with air-bubbles and ova successively escaping, and the external surface was covered by ova thus conveyed to the exterior. Those specimens which were black and putrid, and appeared to have been dead some time, exhibited the horny tubes nearly devoid of ova. After a time, the horny basis itself becomes softened, and appears to undergo decomposition. During the following Spring, according to the evidence of Vaucher and Raspail, the horny envelope of each ovum separates into two

lateral halves adhering on one side as by a hinge. From these valves a small gelatinous tubercle projects, which soon expands into a distinct polype, and gradually becomes elongated into a tubular form. From the sides of this tubular polype small gelatinous buds soon appear, and these again become developed into distinct polypes; the tubular parietes gradually become consolidated and form the horny basis of the mature Alcyonella.

In this instance are exemplified the two modes of reproduction common to some Zoophytes. First, the oviparous, which in Alcyonella according to Raspail takes place only in Spring.* Secondly, the gemmiparous, which proceeds throughout the entire period of growth.

LITERARY HISTORY OF ALCYONELLA.

I will conclude these remarks by a brief sketch of the literary history of Alcyonella and of the

* In November, 1835, I placed several portions of dead Alcyonella in a large jar of water to be reserved for experiment in the ensuing season; and, on the tenth of August in the present year, on finding that the Alcyonellæ had begun to appear in the pond at Little Woodhouse, I took a portion of one of the softened putrid masses, with ova adherent to its surface, and placed it in a glass of clear water, in a window exposed to the sun. On the eighth day, amongst the ova which had floated to the surface of the water, a few were observed to have separated into two halves as represented by M. Raspail, and from each of these a distinct well-formed polype protruded. The tentacula were perhaps a little shorter than in the more perfectly developed Alcyonellæ. In a few days these polypes died. The experiment was repeated on the 23rd of August. On the 30th several ova exhibited a separation into two valves, between which a translucent papilla was situated, and on the following day three or four perfect polypes were visible. On the 5th of September, the day on which this note is written, there are ten or twelve polypes observable in the midst of about two hundred ova, floating on the surface of the water. No development of buds can yet be detected.—*Sept. 5,* 1836.

generalizations adopted by Raspail in reference to this and several neighbouring genera.

M. Bosc found in the pond of Bagnolet, near Paris, several irregularly shaped masses covered with pentagonal pores, and sent them to M. Bruguiére for representation in the Encyclopédie Methodique, with the compilation of which the latter was then engaged. He found that each cellule was the habitation of a polype, which he represented as consisting of fifteen to twenty filiform tentacula, each terminated by a rounded head. He placed the animal amongst the Alcyonia, and denominated it Alcyonium fluviatile.

Lamarck, having examined living specimens from Plessis-Piquet, approved of and preserved the characters assigned to it by Bruguiére, but constituted for it a new genus under the name of Alcyonella, which he placed at a great distance from Alcyonium, but very near to Plumatella.

Lamoreux in his turn examined living Alcyonellæ from the neighbourhood of Caen, and considered the plates of Bruguiére so faithful that he thought he could not render a better service to science than to copy his plates without alteration.

Raspail next devoted himself to the examination of Alcyonella throughout the greater part of the year 1827, and, instead of recognising the polype as represented by Bruguiére, discovered a polype closely resembling the polype á pannache of Trembley, and by a long process of investigation arrived at the conclusion that Alcyonella was only a more aged form of Trembley's polype, which in different stages

of its development successively passed through various forms which have erroneously, in his opinion, been elevated to the rank of distinct genera or species.

In order to divest the animal of the confusion of what M. Raspail regards its synonyms, he endeavours to trace it from the egg through its different stages of development.

In the first instance, he confirms the observation of Vaucher, that in Spring each granule opens at the sides and separates into two valves, from which becomes protruded a little polype, a Tubularia enveloped in its sheath, and prolonged in a straight line along the stone.

Soon this polype begins to develope a lateral bud, at the extremity of which tentacula gradually appear, and the bud at length assumes the character of the parent polype. When these two polypes are of uniform size, there is produced a figure precisely identical with the *Leucophra Heteroclita* of Müller, an animal which Müller found in the same vessel with some Tubulariæ. The description given of *Diffulgia* by Lamarck, shows that it is undoubtedly identical with the Leucophra Heteroclita of Müller, and consequently, according to Raspail, is but a form of Alcyonella.

Soon another tubercle announces the formation of a third polype, and we then perceive the *Trichoda Floccus* of Müller, which he found in the same water with the former, after violently agitating the Tubulariæ.

The animal, according to M. Raspail, continues

to propagate by buds under two different circumstances as to locality; namely, either on the inferior surface of a stone, or on the lateral or superior surface, by which its form is materially influenced.

If the polype becomes developed in a downward direction, as if influenced by gravitation, its buds appear at greater distances from one another, and form ramifications. The tubes formed by the external membrane become firm and solid by age, they cease to increase, and at length serve only as a retreat for the polypes at the summits of the branches. In this case is produced the *Polype à Pannache* of Trembley, and the *Plumatella* of Lamarck.

In the second case, the polype ramifying by its own weight on the superior surface of the stone, produces the *Tubulaire Rampante* of Müller, and the *Tubulaire Lucifuge* of Vaucher. When, however, the new polype, gravitating perpendicularly upon the superior surface of the stone, finds an impediment to its spreading along the surface, either from the number of its own buds, or from other circumstances, its new buds separate less from each other, and as their number increases, they press laterally against each other, their tubes assume a pentagonal form, and we have the commencement of Alcyonella, a state precisely represented by the *bell-shaped polype* of Baker.

At length the tubes become more horny, and of a browner colour; they become more and more extended, forming an incrustation of considerable thickness, having a surface which exhibits numerous

pentagonal apertures, which are the orifices of the tubes in which the polypes are retired. We now have the *Alcyonella Stagnorum* of Lamarck; the *Alcyonelle fluviatile* of Raspail.

ON

THE YORKSHIRE COALFIELD;

BY MR. EDWARD S. GEORGE, F.L.S.:

READ NOVEMBER 11th, 1836.

The late Mr. E. S. George was, from the first foundation of the Society to the time of his death, at which period he filled the office of Curator, one of the most active members of the Leeds Philosophical and Literary Society, and made several communications to it on general and local Geology. The following paper was left by him as a fragment in its present unfinished state, and as such it was read before the Society some years after his death. It appeared after a careful enquiry, that the information collected in it has not yet been given to the public in any other form; it has, therefore, been considered that its publication, even at this distant date, might be materially conducive to the prosecution of those enquiries which seem to form the peculiar province of the local geologist. The section which was intended by the author to have illustrated his treatise, was left in too unfinished a state for publication, even in this form. In other respects, also, it has been thought on the whole advisable not to endeavour to supply omissions, but to put the paper into the hands of the student as it was left by its lamented author; in which necessarily imperfect state, however, it will be found not altogether unworthy of his reputation.

In describing the stratification of a Coalfield, the rocks may upon the surface be traced with greater facility than the Coalseams; they are seen in the outline of the country, and although their thickness is exceedingly variable, yet, they may generally be so far identified as to leave few unconnected intervals.

The basset of the Coals is hid amongst the

soft clays in which they are generally deposited, and if no other means of discovering them than tracing their outbreak were available, the attempt would be nearly hopeless: but, the value of the Coalseams has rendered them an object of attentive research, and the extensive workings every where opened, afford the best opportunities for their exact delineation.

In venturing upon tracing Coalseams throughout an extended range of country, I am aware that I have engaged in an undertaking, the possibility of the completion of which may be doubted.

In the very able papers on the Coalfields of Northumberland and Somersetshire, published in the Geological Transactions, such a work is said to be attended with insuperable difficulties. If I have succeeded in the attempt, the success is in a great measure dependent upon the efficient assistance I have received from every owner of estate, or occupier of colliery in the district.

Before commencing an account of the stratification, it may be advisable to show that some of the seams are continuous, and leave others to be decided in the sequel.

The millstone grit has been found in all the northern English Coalfields; in Yorkshire it forms a thicker bed and occupies a larger surface than in any other situation,—and it is found extending in a continuous chain from near Leeds into Derbyshire. Above the millstone grit, at ..... yards, are two seams of Coal, separated by about ..... yards of measures; in the shale forming the roof of the

upper one is found a fossil shell, the Pecten *papyraceus*, (Sowerby.)

Now this Coalseam is found characterised by the same fossil at the extreme points of the Coalfield, at Moor-Allerton, near Leeds, and near Buxton, in Derbyshire. Applying in this case the principle so successfully employed by Mr. Smith in the elucidation of the rocks of the superior strata, that the enclosed fossils of a stratum are the best test of its identity—we conclude that this is the same seam throughout its whole course, although in one situation it is two feet thick, in another eighteen inches, and in another four inches;—if we examine it by its relation to the neighbouring rocks, we find it always above the millstone grit, and below the flagstone. The flagstone may also be traced continuously throughout the whole Coalfield; and the Low-Moor and Royds seams of coal, which are the next above the flagstone, are also known to occupy the same situation in every part of the coal measures with which I am acquainted.

To trace accurately the basset of every coal-seam, would, if practicable, be a work of immense labour and of comparatively trifling value; every useful purpose is attained by ascertaining the extent and position of the thicker seams. The Yorkshire Coalfield offers several divisions that may almost be considered as natural, and by following their order, we hope to render the delineation of their bassets perspicuous.

The *first* is the millstone grit, which divides the part containing valuable seams from the limestone

shale, in which the seams are thin and of very inferior quality.

The *second*, the beds between the millstone grit and flagstone; the lower part containing the seam characterised by the pecten papyraceus, and the upper part by the hard, fine-grained sandstone called by the miners "calliard," from which so many fine specimens of variolariæ and lepidodendra have been procured.

The *third*, the flagstone.

The *fourth*, the beds between the flagstone and a thick rock, (which it includes,) seen to the greatest advantage upon Thornhill-Lees, at Dewsbury Bank, and at Beeston, near Leeds. This includes the Low-Moor, Royds, and Beeston seams, and some small seams subservient to them.

The *fifth* includes the beds above the Thornhill and Dewsbury rock, (which is the same as the one described by Mr. Smith in his map of Yorkshire, as the Whitley-Hall and Wortley Rock,) to the upper part of a thick, argillaceous sandstone, seen on the summit of Rothwell-Haigh, between Leeds and Wakefield. This includes the Haigh-Moor seam, which is the main coal of the Haigh-Moor, Lofthouse, Middleton, Waterloo, and Garforth collieries, and all the seams between it and the rock before mentioned.

The *sixth*, the measures accompanying the Barnsley thick coal, which is the same as the coals worked at Stanley near Wakefield, at Methley, Astley, and Kippax.

The *seventh*, the beds above the Barnsley coal,

which contain the grit rocks of New-Miller-Dam and Woolley-Edge, with the coalseams worked at Nostell and Shacleston.

* * * * * *

THE MILLSTONE GRIT.

The mill-stone grit is a coarse conglomerate, composed of rounded particles of quartz, feldspar, and mica; it also contains chlorite, oxide of iron, and portions of compound rocks. The feldspar is generally disintegrated, in some cases appearing as a cement. It is, however, frequently crystallized, with worn edges, and of a red colour. The mica is white; the predominant colour of the quartz, which is in the largest proportion, is white; it is also smoky, and I have once observed a minute fragment of rose quartz; when chlorite occurs it occasions green patches, and oxide of iron frequently gives the stone a striped appearance. When recently quarried the stone is soft—some specimens even crumbling between the fingers: in this state it is worked with facility for the purposes of ornamental architecture; it quickly hardens by exposure to the atmosphere, and then rivals granite in durability, resisting in a high degree the action of water. This rock, at the celebrated quarries of Bramley-Fall, near Leeds, is from eighteen to twenty yards thick: below it, in the upper measures of the limestone shale, is a considerable thickness of grit rocks. They may be seen in the precipitous sides of Otley Chevin, nearly two hundred and fifty feet thick, separated only by thin seams of shale from two to six inches

thick. Besides these horizontal seams, the rock is every where intersected by perpendicular fissures, which divide it into blocks of a determinate regular form.

The following is the order in which we propose to delineate the bassets of the strata, commencing at the point where the millstone grit at Scarcroft is covered by the unconformable mass of magnesian limestone, and proceeding in a westerly direction to the Calder. From Scarcroft the course of the millstone grit is nearly due west to Shadwell. Between Thorner and Shadwell it is covered by a detached outlier of magnesian limestone; continuing its westerly course, it passes between Alwoodley and Moor-Allerton, where it is seen in the sand-pits of Black-Moor: along the southern edge of Black-Moor it passes in a southerly direction to the quarries of Meanwood. On this line it passes the summit of Tunilaw-Hill, where it attains an elevation of ..... feet. At Meanwood the course again becomes westerly; and it is seen to the north of Headingley, and in the woods at Kirkstall; it is here extensively quarried. The beautifully picturesque Abbey of Kirkstall, the parish church of Leeds, and most of the ancient edifices of the neighbourhood, are built with this stone, and it has lately been employed by Mr. Chantrell, of Leeds, in building one of the parliamentary churches in a style of ornamental architecture to which it was before considered inapplicable. From the rapid rise of the ground to the north of Kirkstall, being equal to the dip of the strata, the millstone grit is continued

upon the surface northward to Addle and Cookridge. At the latter place a throw or fault depresses the millstone grit at least fifty yards; it is, however, again seen near the summit of Otley Chevin. At Kirkstall-Forge the river Aire passes through the millstone grit, and upon the southern bank are the quarries of Bramley-Fall, from which large quantities of this rock are sent coast-wise to London, and the southern counties.

This is the most valuable of the Yorkshire quarries; the stone is of uniform composition, and is not intermixed with oxide of iron, which often very much deteriorates the quality. In the most solid parts of the stone are enclosed pieces of shale, from the size of a hazel nut to six or eight inches in diameter. From this quarry have been procured the few vegetable fossils I have noticed in the millstone grit. As usually happens in sand-stone, they are uncompressed and in a state of great perfection. Amongst them we may recognise the Sternbergia of Artis and Brongniart (Phytolithus *transversus* of Steinhauer.) Of this fossil a specimen five feet in length has been procured; Calamites .....; and the cast of a furrowed plant, having broader flutings than calamites, and as far as the specimen extends, about two feet without joints, but not having the punctations of syringodendra; in a shale two inches thick, which divides the beds horizontally, is the remains of a stellate plant, supposed by Professor Phillips to be an Asterophyllites, 159 of Brongniart; from some of the grit rocks below the millstone grit on Otley Chevin, I have seen the

remains of Lepidodendron *aculeatum*, and in considerable quantity the apparent remains of leaves of a species common in the flagstone, and which have been referred to the Iris, the plant itself generally converted into a substance resembling mineral charcoal.

From Bramley-Fall the millstone grit occupies both banks of the Aire to near Calverley, and it extends through Kirkstall-Wood to Horsforth; it is there terminated by a throw, which brings down the flagstone to near the south bank of the river at Calverley. The millstone grit is, however, seen on the north bank, and extends by Apperley-Bridge to the north of Bradford. More westward it occupies a considerable part of the surface, but from the great inequalities and many considerable throws, which out of the worked part of the Coalfield are little known, it is impossible to trace it with exactness. It is seen skirting round the hills to the west of Thornton to near Haworth, and by Illingworth through Ovenden to Halifax, which is built upon it.

* * * * * *

SHALES COAL AND CALLIARD BEDS, BETWEEN MILLSTONE AND FLAGSTONE.

Our second division includes the beds between the millstone grit and flagstone; its entire thickness, as seen in the section at Catharine-Slack, near Halifax, is one hundred and ninety-seven yards; from this we may take about twenty yards as the ragstone described as succeeding the flagstone which belongs to it.

This part of the coal measures is characterised by several remarkably hard, fine-grained sand-stones, called by the miners "calliard," they are almost entirely composed of grains of silex, united without cement, and by exposure to the temperature of ignition their cohesion is destroyed, and they are reduced to an exceedingly fine sand. They alternate with very black shales, which contain a considerable quantity of carbonate of iron disseminated throughout them and in the shape of a poor iron-stone. Below the flagstone, and the ragstone beneath it, in one hundred and forty-seven yards of measures, there are only eighteen yards of sandstone, the remainder being entirely composed of shales alternating with "calliards." The uppermost bed of "calliard," which is three yards thick, is known throughout the Coalfield; it may be traced almost without intermission from Bramham-Moor, where it is covered by the magnesian limestone, into Derbyshire; it is every where filled with the fossil remains of plants.

In this division of the measures there are only two workable seams of coal; the first is about forty-one yards above the millstone grit; it is black, soft, and free from pyrites; it contains a considerable portion of mineral charcoal; its floor is a soft shale, containing much mica; its roof a bituminous shale, in which I have noticed lepidodendron. At twenty-five yards above this coal is a hard "calliard;" this stone is a mass of fossil plants, Variolaria *ficoides*, (Sternberg,) and frequently contains balls of iron pyrites so hard, that in a boring made near Halifax, the

penetrating of this bed, which was about one foot thick, cost seventy guineas. Upon this "calliard" lies the Halifax or pecten coal, which at Catharine-Slack, where it is extensively worked, it is two feet three inches thick. It is a hard coal, and contains a considerable quantity of iron pyrites, in the shape of nodules in the roof, and gilding, in a beautiful manner, the seams of the coal; it also encloses gypsum, sometimes forming fine crystals; the presence of so large a quantity of earthy matter, in other parts of this seam, renders it of little value. In the roof of this coal are every where met with the remains of a shell, which Mr. Sowerby considers a pecten; (it appears questionable whether its broad hinge bears a sufficient analogy to the type of the genus pecten;) and from its delicate markings and fabric, has named, Pecten *papyraceus*. The specimen which he figured was, I believe, from the Woodwardian Museum, and there is reason to believe it was originally from the coal measures of Derbyshire; I have seen such from the neighbourhood of Buxton. Accompanying the pecten is another fossil which very closely resembles the genus ostrea. The shale which contains these fossils is about one foot thick; immediately above it is a very black shale about three inches thick, and which is filled with a tuberculated ammonite. Besides these, the nodules of pyrites which lie at the top of the coal contain Ammonites *Listeri;* the only vegetable relic found in connection with the fossil shells is a small quantity of mineral charcoal.

The next bed worthy of particular notice is

about fifteen yards above the pecten coal; it is the principal "calliard." The lower part of the rock is composed of grains of silex, with a few interspersed plates of mica united without cement; it is from three to four feet in thickness, and abounding with the most splendid specimens of Variolaria *ficoides;* indeed some parts of the bed are a mass of plants, in others, where a single plant is detached, the spines from one to two feet in length may be observed shooting into the surrounding rock, the Phytolithus *verrucosus* of Martin* is figured from a specimen belonging to this rock in Derbyshire. Accompanying Variolaria *ficoides* specimens of calamites, of from three to five inches in diameter, are frequently discovered. The exterior of these fossils is covered by a carbonaceous coating, which gives the whole rock a dark appearance; the only trace of internal structure is an apparently pith-like substance contained in Variolaria *ficoides*, and which has been correctly figured by Martin. This part of the bed is separated by a seam of coal, two inches thick, from the upper part of the bed which is of similar composition, and equally rich in organic remains; the principal of these is Phytolithus *cancellatus*, the Lepidodendron *aculeatum* of Sternberg, of which the Museum of the Leeds Philosophical Society possesses a specimen four feet in length; I have also observed Lepidodendron *obovatum* and Lepidodendron *parmatum* in these measures; no remains of syringodendra or filicites have yet been discovered. This division of the coal measures generally occupies the elevated

* Martin's Petrificata Derbiensia.

ground on the border of the moor lands, and does not any where form a great breadth of surface. A denudation of the magnesian limestone considerably within the line of its range first exposes these measures, and the "calliard" has been quarried on Bramham-Moor to repair the roads, and followed below the limestone. They pass from under the magnesian lime upon Win-Moor, and continue in a westerly direction to the north of Seacroft, where they come in contact with throw, No. .....; by this derangement the basset is carried to the northward, and the "calliard" is seen in the front of Roundhay-Park, (Mr. Nicholson's;) they proceed still West to Moor-Allerton, where the hard stone or "calliard" below the Halifax or pecten coal is quarried; the coal in this situation is only four inches thick; it may, however, be with certainty identified by the pecten and ammonite accompanying it; the pyrites contained in its seams and roof, and its iridescence, being in almost every situation in which it has been discovered a peacock coal; this last character, I am aware, is not to be relied upon in the absence of others, being in a considerable degree accidental; it is, however, possessed by this coal in a remarkable degree. Some borings have been made to the north of Moor-Allerton, and the bed below the pecten coal was met with, but not worth working. The course of these measures is now South-west to Headingley-Moor, where the "calliard" is thicker than in any other part of its course; it is from the quarries here opened that the fine fossils described as belonging to this bed

have been procured; the upper part is about three yards thick, makes excellent paving stones, and the lower part is used for the road. By reference to the sections it will be seen that a stone lies below the two inches coal at Horsforth, as well as on Headingley-Moor, while at Catharine-Slack its place is occupied by a black shale.

The course of the "calliard" is from Headingley-Moor to the river Aire, which it crosses about two hundred yards east of the toll-bar at Kirkstall; it is afterwards south-west to Stanningley. The pecten coal has been formerly got in Kirkstall-Wood to the north of the Abbey. A patch of these measures is found considerably to the north of the basset line at Horsforth and Rawden; their appearance in this situation is occasioned by a throw, No. ..... which depresses the millstone grit. At Rawden the coal is much thicker than at Moor-Allerton, being sixteen inches, but not near so thick or of so good a quality as at Catharine-Slack; this increase in the thickness of the seam of coal illustrates the gradual thickening of the measures in their course westward, a fact we shall subsequently attempt more fully to establish. To the north of Rawden, and in the line of throw, No. ..... the pecten coal is found at Cookridge, and stretching towards Bramhope to the north-east and Guiseley to the north-west, it is in both directions thin and very much confused by throws.

The pecten coal is again found to the south of the Aire at Idle, where it is worked, and at Wind-Hill. At Baildon, and in a line extending from

Bingley and Keighley towards Denholme and Halifax, it is frequently met with. In this part of the Coalfield it becomes a valuable coal, supplying the populous district to the west of Bradford and Halifax. It occurs in patches in many places on the western moor lands; it is at present worked upon Rumbold's-Moor, between Keighley and Ilkley, and is, I believe, the coal found on the summit of Pennigant. Large collieries are opened at Queen's-Head, a village on the summit of Clayton-Heights, and at Catharine-Slack, near Halifax; the pits are sunk from the top of the flagstone, a depth of one hundred and sixty-five yards, the coals are brought to the surface by adits, the entrances to which are in the deep valley of Ovenden. From Catharine-Slack these measures extend to the west of Halifax through Southowram, where are collieries to the Calder at Salterhebble, and may be traced on the western border of the Coalfield by Penistone and Sheffield into Derbyshire.

FLAGSTONE ROCK.

The FLAGSTONE is composed of very fine grains of quartz, felspar, and probably compound rocks, with plates of mica, united by an argillaceous cement, to which, and the abundance of mica, the slaty structure is owing. The entire thickness of this bed is about twelve yards; it is divided into three parts—"Rag," flagstone, and roofing-slate; the lowest "Rag," so named by the workmen from the absence of regular partings, and its unfitness for the purposes of architecture, contains many fossils. The

next part of the flagstone is divided by seams both vertical and horizontal; these, from their almost perfect evenness, render the stone peculiarly applicable as a flagstone. The number of horizontal partings increase rapidly in the upper part of the bed; at first they are from ten to fifteen inches distant; the stone is then worked as ashler, it bears a good polish, and is much employed in ornamental architecture; the upper part used as a roofing-slate, is about one inch thick, and may be split into plates not more than the eighth of an inch in thickness.

The fossils of this rock are numerous. They are Phytolithus *tessellatus* and *imbricatus* of Martin and Steinhauer; they are Lepidodendra of Sternberg; the Phytolithus *acutulinum* of Martin; this fossil seed vessel is frequently accompanied by parts of a leaf resembling that noticed by Sternberg as approaching to the iris; this seed vessel is found in large quantities in a bed about two inches thick, at from five to six yards from the top of the flagstone.

The Flag-stone is first seen in a denudation of the magnesian limestone on the road from Redhall to Barwick-in-Elmet; it passes from under the magnesian lime on Win-Moor, on a line a little to the north of the York and Leeds road.

It passes nearly due west to Seacroft, where it is covered by a detached outlier of the magnesian lime-stone; after leaving throw, No. ..... it is seen on the Roundhay road, and has a course through

Roundhay-Park, at the southern part of the lake —it is here seen as a shelving rock; it may be traced through Gledhow, the southern part of Chapel-Allerton and Potternewton to Woodhouse. The flagstone forms a series of rounded hills, subordinate to the range of millstone grit, and of which it generally occupies the southern slope.

In the quarries of Woodhouse, near Leeds, the flagstone is of excellent quality; flags ten feet square, and not more than six to eight inches thick, may be at all times procured, and flags of two and three inches thick in the greatest abundance. The colour of the stone is a pale straw, having an inclination to yellow.

From Woodhouse its course is south-west; it is seen at St. Peter's Hill, near Leeds, and crosses the river Aire at Spring-Gardens; it may be traced along the southern bank of the river to Armley-House, the seat of Benjamin Gott, Esq., which is built upon it. The course of the flagstone from Armley continues south-west to the quarries of Park-Spring, near Farnley; the stone at this quarry is of excellent quality, being very close grained, harder than at Woodhouse, and of good colour; it is employed throughout the county as an ornamental stone, and large quantities are sent to the metropolis.

From Park-Spring it extends in a westerly direction to Pudsey, and is seen much to the north, on the banks of the Aire at Calverley, by the great rise on the surface it is found occupying the summit of Rawden Billam about three miles north of its line of

basset. From Pudsey the flagstone extends through Idle to the north of Bradford; at both the last-named places it is extensively quarried for flags; the stone in its course westward has become much harder, from an increase in siliceous matter, and also apparently from an admixture of finely-divided particles of iron-stone. It is from Idle and Bradford, and the quarries in their neighbourhood, that the Yorkshire flags, so well known in the metropolis, are principally obtained. The flagstone covers a large district to the West of Bradford; it is found on the summit of Baildon-Hill, north of the Aire; it is seen at Shipley, at Thornton, and Denholme; it occupies the summit of Clayton-Heights. At Catharine-Slack, near Halifax, pits are sunk through it to the pecten coal, and passing through Northowram, Hipperholme, and Southowram, it is worked at the celebrated quarries of Cromwell-Bottom, near Elland, on the Calder.

FOURTH DIVISION.

The fourth division extends from the flagstone to a thick argillaceous sand-stone, known as the Dewsbury Rock, and includes the seams worked at Low-Moor, Royds, and Beeston; the entire thickness is about two hundred and fifty yards. The coals of this tract are of a much superior quality to those below the flagstone; they are highly bituminous, and amongst them are some of the best coals of the district. Ascending from the flagstone are measures, chiefly of shale, forty yards to a bed of potter's clay, it is the only true potter's clay of

the Coalfield, and is employed in the manufacture of coarse earthenware and fire-bricks; it contains large quantities of the remains of Variolaria *ficoides*. It is the seat of the Low-Moor coal, so called from its supplying the iron works of Low-Moor, near Bradford, with their furnace coal. Like most of the coals of the Yorkshire strata, it is the slate coal of mineralogists; it makes an excellent coke, which, from the absence of sulphur and earthy matter, is peculiarly suitable for the making of iron, it cakes in burning and leaves a bright red ash.

The roof of this coal is a bituminous shale about one foot thick in the Low-Moor section; it is called black bind; no fossils have hitherto been observed in it; upon it at Low-Moor and Bowling are beds of shale alternating with their beds of sandstone, and succeeded by a thick bed of blue shale, containing several thin beds of ironstone, which is not worked; the only fossil I have observed in this bed is Unio *acutus*, which I obtained from a well in Leeds. At Leeds the beds of indurated shale and sandstone are wanting, and the bituminous shale is covered by the blue shale containing ironstone. The next bed is a sandstone, of variable thickness; at Low-Moor, it is nine yards; at Bowling six yards; whilst at Grove Terrace, in Leeds, it is twenty yards; it is succeeded by a bed of indurated potters' clay, ("white earth," or "spavon," of the miners,) which is the floor of the Royd's coal. The Royd's coal is known as the black bed of the Low-Moor and Bowling collieries; it is a black, bituminous coal, soft, and yielding a considerable portion

of ashes. At Low-Moor, it is two feet ten inches thick.

Immediately above, and forming the roof of the Royd's coal, is a bed of shale containing ironstone; it is this bed that has supplied the iron works in the northern part of the Coalfield; it is now extensively worked at Low-Moor, Shelf, and Bowling; the two former having eight, and the latter three blasts; the ironstone of Tankersley, which supplies the furnaces of the neighbourhood of Sheffield, is, I believe, higher in the series; separated from these ironstone beds (which from their dark colour are called the black stone) by shales alternating with sandstones, (see Low-Moor section,) is a bed of blue shale containing a white ironstone, not so rich in iron as the black, but, like it, filled with the remains of fossil plants; they generally form the nucleus round which the ironstone is deposited. These ironstones have yielded a greater number of fine specimens of organic remains than any other part of the Coalfield; they are Calamites *pseudobambusia*, (Sternberg,) Lepidodendron *aculeatum*, L. *obovatum*, L. *parmatum*, (the Phytolithus *parmatus* of Steinhauer) L. *lycopodiodites*, Rhytidolepis *tessellata*, and another species of Rhytidolepis, Variolaria *ficoides*. The ferns which are first seen in these beds are not so numerous as in the higher parts of the measures; they are, however, of great beauty. I have observed a Pteris, and Osmunda *gigantea;* there are also the remains of one or more stellate plants, the Phytolithus *stellatus* of Martin. Of the animal remains Unio *acutus* is found in great abundance in the

black ironstone, and Unio *subconstrictus*, which, as far as I have been able to make out, is restricted to the white ironstone. Besides these, one of the specimens of the head of a fossil animal, of which an account was sent to the Geological Society, is from these measures. I must confess myself not sufficiently acquainted with comparative anatomy to determine to what class of animals this specimen belongs; it is, however, in such a state of singular perfection, the teeth, bones of the jaw, and head, and the sutures of the skull, are so clearly developed as to occasion little difficulty to a person acquainted with the anatomy of the tribes of animals, to which it may be supposed to approximate. I beg to refer the Society to the drawings which accompanied the account of this animal. The remains are, with the others that have been enumerated, deposited in the Museum of the Leeds Philosophical Society.* Between the two ironstones is a seam of bad coal, or rather black earth, which I only notice on account of its afterwards becoming a workable seam of coal. The next stratum of importance is an argillaceous sandstone: in the Low-Moor section it is said to be eight yards thick; its entire thickness is twelve or fourteen yards; it is used as a building stone and for the erection of blast furnaces.

The distance from the Royds to the Beeston seam is eighty yards; this is ascertained by borings made below the Beeston seam at Tong and in some

* The specimen alluded to has since been examined by Professor Agassiz, of Neufchatel, who has named it Megalichthys Hibberti.

other situations; the borings were made many years ago: I have not succeeded in obtaining any of them. I believe that between the thick argillaceous sandstone and the Beeston seam is a thin coal.

The next seam of coal, or rather collection of seams, is of very variable thickness: I shall describe it as it is found at Beeston, where the section crosses it; its changes will be better examined in tracing its course. Commencing with the lower part, there is coal nine inches parting half an inch, coal seven inches parting one inch, coal ten inches; forming a thickness of two feet three and a half inches of good hard coal, which burns to a very white ash: the next is coal six inches parting two inches, coal seven inches; one foot three inches of coal of very inferior quality, soft, and indeed very little better than a black earth; it is succeeded by parting two inches, coal one foot four inches; this coal is rather soft, and burns with a white ash; a parting of three inches separates it from the upper bed two feet three inches thick, of good quality, moderately hard, and a caking coal, it yields a large quantity of gas and leaves a grey ash.

Above the Beeston coal are measures in which sandstone predominates, extending to the floor of the Haigh-Moor seam, a thickness of ninety-seven yards, without any workable bed; the sections from the Haigh-Moor coal at Middleton and at Garforth illustrate these measures: amongst them is the thick stone which forms so conspicuous a feature in the country at Thornhill-Lees, to the south of the Calder, and at Dewsbury on its northern bank. In

the Middleton section it commences with the Whine and White post with water, and extends through several of the following measures, as indicated by the parts joined by a bracket. The same alternations with shale (grey metal) is seen on Dewsbury-Bank, in the part cut through by the Leeds and Dewsbury road.

In tracing the course of this division of the coal measures, we shall first describe the basset of the Low-Moor and Royds seams, and afterwards that of the Beeston.

Low-Moor and Royds Seams.

Commencing at the point where the Low-Moor coal is covered by the Magnesian limestone, near Kidhall, on the Leeds and Tadcaster road, we find to the westward, on Win-Moor, many traces of old workings extending from a few hundred yards west of Kidhall to Seacroft. In a late trial respecting the manorial rights it was proved that coals had been worked on this tract four hundred years ago. The length of time which has elapsed since these pits were worked does not allow of our obtaining much information on the depth of the coal in the accompanying measures. To the west of the great throw 29, a throw up to the west of ninety yards, we find the Low-Moor seam bassetting near the village of Seacroft; in this part our knowledge of its course becomes more accurate, it being now worked in shallow pits of from nine to twelve yards in the valley at Roundhay; between them and Seacroft are the remains of much more extended

workings not only of this coal, but also of the Royds seam and the ironstone above it, which were at Seacroft converted into iron.

The coal for making the iron at Seacroft was obtained from the Beeston seam, the Low-Moor being at Roundhay of inferior quality and not more than sixteen to eighteen inches in thickness. The line of basset extends from Roundhay in a south-westerly direction to the northern part of Leeds, where it is constantly passed through in the sinking of wells; its thickness in Leeds is from fifteen to eighteen inches. In Park-Lane, in Leeds, the potter's clay beneath the coal has been long dug for fire-bricks. In the centre of Leeds the Royds coal and ironstone has been worked, and the old sinkings are often met with in digging foundations for houses. From Leeds the course is more southerly to the village of Wortley, where are many coal-pits sunk to the coal and potter's clay; the quality of the coal is here much improved, and its thickness is about twenty inches; on the summit of Wortley-Hill the Royds coal is passed through in sinking to the Low-Moor seam; it caps the hill; its greatest depth is twelve yards. In the valley between Wortley and Beeston the Royds coal has been much worked, supplying the ironstone for the Royds Iron Works, the engine pit was near the foundry on the Beeston side of the valley, and the coal was got to its basset north and north-west. The ironstone at Royds afforded many fine organic remains. From Wortley the basset extends south-west through the valley between Fulneck and Farnley, in some cases

approaching to Fulneck, and continues to Tong, where it comes in contact with Fault 23. The Royds coal bassets at about half the ascent of the hill on the Farnley side of the valley, and is worked by levels under Farnley-Park wall. Its contact with Fault 23 is to the east of the village of Tong.

By this fault which is one of one hundred and twenty yards down to the south, the basset of the Low-Moor seam is carried westward about three miles, to near the Bowling Iron Works; from the latter place it extends in a northerly direction across the road from Bradford to Eccleshill Common, it is there shallow and much broken by faults of small extent. Near the Bowling Iron Works the Royds seam bassets in a line about half a mile to the north of them.

To the south of fault twenty-three the thickness of both seams is increased; the Low-Moor seam being two feet three inches, and the Royds two feet ten inches thick; their quality is also much improved, the first being almost entirely free from earthy matter and pyrites, render it an invaluable coal for the reduction of ironstone. It is a fact well known to every coal-miner, that faults frequently alter not only the thickness but the composition of the coal seams; whether the greater value in these seams at Low-Moor, compared with their little value at Roundhay, is occasioned by the fault, may, however, be questioned; the change in quality and thickness is very gradual, as will be seen by recurrence to the sections and that part of the seams at Bowling which is north of the

fault, is of a quality equal to the coal to the south of it. The change is one that was noticed in the Halifax coal below the flagstone, and which we shall again notice in speaking of the Beeston seam.

In the Bowling colliery the principal pits are to the south of the iron works, extending to near the village of Bowling, where they approach the workings of the Low-Moor Company. There are not in this colliery any faults of magnitude.

From Eccleshill-Moor the basset of the Low-Moor seam is in a south-westerly direction to about fifty yards east of the church at Bradford, it extends to the east of the town of Bradford, and to the north of the villages of Little and Great Horton, skirts along the eastern declivity of Clayton-Heights, and in a line to the south-east, to the west of Shelf, and to the east of North-owram and Hipperholme, touches upon the Calder at Brighouse. Along and within the whole of this basset line these valuable coalseams are extensively worked, supplying the manufacturing district of Bradford, and the large iron works at Bowling, Low-Moor, and Shelf. In the Low-Moor colliery are few faults of any magnitude; in some of the faults marked upon the map considerable quantities of galena have been found, blende is crystallized upon many organic remains; and the interior of Unio *acutus* found in the black ironstone, frequently contains fine crystals of quartz. It has been remarked that the ironstone is more abundant and of better quality in those situations where it approaches the surface.

To the west of Bradford, at Allerton, is a considerable patch of the Low-Moor seam, and about Thornton it is found in a few situations.

On the north bank of the Calder at Clifton, the Royds seam is worked; it is two feet six inches thick; at a distance of forty-six yards below it the Low-Moor seam has been sunk to; its thickness is twenty inches, and the quality very inferior; between the coals the measures are similar to those at Low-Moor. On the south bank of the Calder the Royds coal is worked at Hopton.

The short argillaceous sandstone which was noticed as occurring at Wibsey, is seen in nearly the same position as regards the Royds coal at Mirfield; it is a pale straw colour, much variegated by stripes of oxide of iron.

Beeston Seam.

The Beeston seam, which we have so called from its being extensively worked at Beeston, near Leeds, and being known by that name in the collieries of the northern part of the Coalfield. It has been for many years worked under the magnesian limestone on the Garforth and Parlington collieries; many of the pits have been sunk through the magnesian limestone. The workings have not been extended to any great distance, being stopped by the fault No. 37, beyond which, until lately, the general but erroneous opinion that the coal was of no value below the limestone, has prevented any trials. Some borings have been made at Micklefield, where it is probable that the Beeston seam

was met with at one hundred yards, and others near Sherburn. The basset of this seam emerges from the magnesian limestone at a few hundred yards west of Parlington, and to the south of the road from Parlington to Garforth, it proceeds due west to the south of the village of Scholes to Seacroft, where it touches upon fault No. 23. Within this basset line are the collieries on this seam, formerly worked at Parlington and Seacroft, and the one now working at Manston. At Manston the Engine Pit sunk near the basset of the Haigh-Moor seam, is ninety-five yards deep. In a quarry near Lazencroft may be seen the thick argillaceous sandstone, which terminates this division of measures; it is also seen along the crown of the hill from Lazencroft to near Garforth.

This coal is thrown out by fault No. 23, along a line from one and a half to two miles in length; it is first seen in a detached patch, capping the Black-Bank, a hill to the east of Leeds, and it has been bored to at Osmondthorpe and Knowstrop. Its basset crosses the river Aire about one hundred yards south of the Leeds locks, and passes in a southwesterly direction, east of the village of Hunslet and south of Holbeck, to the western declivity of the hill at Beeston. Within this line of basset the coal has been for many years worked,—formerly in Hunslet, where it was nine feet thick, and at present, at the Beeston-Park Colliery; there are also a considerable number of shallow pits near the edge of the basset. In the Beeston-Park Colliery the lower part of the seam divides from the

upper one; the division increases in the course southward; and at Churwell, about one mile to the southwest, it is enlarged to nine yards, thus forming two seams. The basset extends from Beeston west, through the valley between Wortley and Farnley to fault No. .....; within this line are the Farnley, Churwell, and Gildersome collieries.

To the south of fault No. ..... there is a considerable difficulty in accurately tracing the course of the Beeston seam. This is principally occasioned by the thickening of the coalseams in their course to the westward, which was shown to occur both in the Halifax and Low-Moor coals, and thus many seams that are not worth working in the northern part, and are scarcely noticed in borings and sinkings, become of importance, and consequently the number of workable seams is increased. The division in the Beeston seam noticed as occurring in the Beeston-Park Colliery, and which, south of the Calder, forms three or four seams, adds to the difficulty. We will as briefly as possible sketch the changes in the Beeston seam on both sides of Fault No. .....

In recurring to the sections of which I have procured as large a number as possible, it will be seen that in the northern part of the Coalfield, this seam is of variable thickness; at Garforth it is said to be five feet, that is, I believe, workable coal, the entire thickness being from six to seven feet, it is of the same dimensions in the Manston colliery, where it forms ..... beds; at Hunslet it was nine feet, and at Beeston it is eight feet one inch and

a half. Now in all the above situations no doubt can be entertained of its position; it will be seen that all the borings commence in or have passed through the Haigh-Moor coal, consequently they must be below that seam: that it lies above the Royds seam is ascertained by borings formerly made, and by the Royds coal being traced in many situations dipping under the Beeston. We conclude that in the northern part of the Coalfield the Beeston seam lies between the Haigh-Moor and Royds. But to the south of fault No. ..... some coalseams are met with that are not known to the north of it, and the Beeston as a thick seam is no where to be found.

We have seen the Royds coal traced to the Calder at Clifton, and we shall afterwards see that the Haigh-Moor seam approaches the Calder near Dewsbury; it remains to determine what are the coals between Clifton and Dewsbury. The Royds coal is worked at Clifton and Hopton; above it fifty-two yards, is a seam of coal worked on Mirfield-Moor; the same coal is sunk to at Hightown, and to the west of Cleckheaton it is from twenty to twenty-six inches thick; it is worked south of the Calder at Hunger-Hill, and has been sunk to at Thornhill; above that is the middle bed of the Calder Iron Works, two feet three inches thick; it is seen in the Thornhill section; at eighteen yards higher is Mr. Ingham's Cromwell coal at Thornhill; it is the upper bed at the Calder, where it is one yard thick; it is met with at Daw-Green, near Dewsbury, Birkenshaw, and at many of the

intermediate places; it is hard, having in its centre a band one inch thick, and burns to a pure white ash. That this is the lower part of the Beeston seam is corroborated by an examination of the measures to the southward at Kexborough; it is supposed by miners that the Cromwell coal is the same as the Silkstone; indeed it might be easily proved, but since the proof would involve the examination of an extensive section, I shall for the present defer it, merely giving a section of the measures at Kexborough from the surface.

Ten yards from surface, Tankersley Iron Bed.

Seven yards below, the Flockton upper seam, the same as the stone coal two feet, earth two feet, black coal one foot four inches. Now here the stone coal is changed to slate coal; it will be remarked how closely it agrees with the upper part of the Beeston seam.

Sixteen yards below, Flockton low seam.

Thirty-four yards below, three feet coal, (the Dodsworth.)

Ten yards below, ten inch ironstone.

Nine yards below, Silkstone coal.*

* The following are the measures given in a neighbouring colliery.

Coal two feet four inches.
Parting one foot seven inches.
Coal seven inches.
Stoneband seven inches.
Coal one foot seven inches.

The following are the measures of the Silkstone coal.

Coal six inches.
Parting two inches.
Coal one foot five inches.
Parting four inches.
Coal one foot eleven inches.

At ..... yards above is a coal of very variable thickness and quality; in some situations it is nine feet thick, and in the same colliery, in a continuous working, it is not more than three inches; this occurs at Daw-Green, near Dewsbury, it is the two yards coal at Birkenshaw and Gomersall, while in the Thornhill section it is only three quarters of a yard; it is succeeded, at thirty-three yards, by the best seam in the Coalfield; it is the Mill-Bank coal at Thornhill, where it is twenty-six inches thick; at Flockton it is twenty inches thick, and is worked at Popeley, near Birstal; above it twenty yards, is a coal well known in the district we have been describing, it is the stone coal, and is in two beds; the lower part of the seam is black or slate coal two feet, earth one foot; stone, or cannel coal, from one foot six inches to two feet; it is first seen at Adwalton, on the south side of fault No. ..... and it extends through Birstal, Morley, Batley, and Dewsbury, to the collieries south of the Calder. At twenty-two yards above the stone coal is a thin seam of variable thickness; it is the "Parson's" coal at Thornhill, and is twenty inches thick; it is also worked on Dewsbury-Bank at fifty yards below the thick argillaceous sandstone, which is the brown rock of the Thornhill section, and which forms so conspicuous a feature in the country at Thornhill-Lees, and may be seen thrown down by fault No. ..... into the valley at Emroyd. The same stone is seen on Dewsbury-Bank below the Haigh-Moor coal, and forming a ridge to the north of the Calder from Dewsbury to near Horbury-Bridge.

Supposing the Mirfield-Moor bed and the middle bed of the Calder Iron Works to be the seams between the Royds and the Beeston, (and such seams although not quite so thick, are known to exist in the northern part of the Coalfield ;) there are the beds forming the Beeston coal for the remaining seams in the Thornhill section. Without endeavouring to trace an exact similitude in coals deposited under such different circumstances, I shall only remark that the Cromwell coal, the lowest of the coals, bears a remarkable resemblance to the lower part of the Beeston seam ; at Beeston-Park are two partings, one of an inch, and a second of half an inch ; in Middleton there is but one ; and at Thornhill, in the centre of the coal, is a band an inch thick, the coals agree in being hard and in yielding a white ash. Nor is the occurrence of a stone coal in these measures any objection to their similarity, since it is well known to all practical men that the change from black coal to stone coal is not of unfrequent occurrence ; an instance may be noticed in the Waterloo Colliery, near Leeds ; the Haigh-Moor seam is, in some parts of that colliery, almost half stone coal, and in other parts not a trace is to be met with.

Of this division of measures we have instances not only in this but in other Coalfields ; Mr. Winch, in his paper on the carboniferous series in Northumberland, notices several instances. In the Dudley Coalfield many seams are united to form the thick bed. And in the Yorkshire Coalfield the thick Barnsley coal separates, forming the seams worked

at Crigglestone, Stanley, Methley, and Astley. This change takes place in an opposite direction to that of the Beeston; the measures of the Barnsley coal opening to the north, whilst the Beeston enlarges to the south.

That the Thornhill measures are below the Haigh-Moor is proved by the boring at Simpson's Spring, in which the "Parson's" coal and the stone coal are passed through.

FIFTH DIVISION.

The fifth division extends from the Dewsbury rock to the summit of a blue argillaceous sandstone seen at Rothwell-Haigh, on the Leeds and Wakefield road; its entire thickness is about two hundred yards. Above the Dewsbury rock are measures principally of shale, and some thick bands of stone, which contain a thin seam of coal, to the Haigh-Moor coal, which is the Main coal of the Garforth, Waterloo, Middleton, Rothwell-Haigh, Ardsley, Lofthouse, Haigh-Moor, and Wakefield Outwood collieries, and from it the manufacturing districts of Leeds and Wakefield receive a considerable part of their supply. The seam varies from four feet to six feet in thickness; it is a fine, bituminous, bright coal, without earthy partings; it cakes in burning, and when consumed leaves reddish coloured ashes. In this seam the slate coal of which it is composed frequently becomes changed into cannel; this change takes place at Waterloo, near Leeds; in one part of the colliery nearly half the seam was cannel. The floor of the Haigh-Moor coal is an indurated

potter's clay, which contains some thin partings of coal; these sometimes unite, and consequently increase the thickness of the seam. The roof is a bituminous shale, frequently containing nodules of ironstone, and rich in the remains of fossil plants.

In this part of the Coalfield the greatest number of coalseams occurs; to describe each of them would too long detain the Society, and they will be seen by a reference to the Garforth and Middleton sections. Above the Haigh-Moor coal are measures principally of stone; their thickness increases to the south-west, being about thirty yards at Garforth, thirty-four yards at Middleton, and forty yards upon Wakefield Outwood; to a bed of coal varying much in quality and thickness at Middleton and the neighbouring collieries it is two feet ten inches to three feet two inches, and of a good quality; it is a black coal, yields a considerable quantity of white ashes, and is much employed as fuel for steam engines. It is the Little coal of the Middleton and Rothwell-Haigh, and the "Hardband" of the Garforth collieries. Above it are several seams alternating with shale and sandstone (which are worked in situations where, from their proximity to the surface, the operations of mining can be carried on at a trifling expense,) to a bed about a yard in thickness, known in the Middleton workings as the forty yards coal. In the tunnel at Middleton is a fine section (one mile in length) of this coal, and a good opportunity is there afforded of observing the faults and other accidents which occur in coalseams. In this coal are two partings; at Middleton they

are seen as a parting of shale two to four inches thick, and a hard stony band contained in the coal about one inch in thickness. The forty yards coal is of very inferior quality, from a large admixture of iron pyrites. Forming the roof is a bed of shale, two yards thick, the lower part of which contains some fine fossil plants, and the upper part is filled with the remains of Unio *subconstrictus*. Above the forty yards coal are thirty-seven yards of measures to the twenty-seven yards coal, which, with an accompanying bed of ironstone, has formerly been worked at Middleton. Some thin beds of shale separate the last named seam from the thick blue argillaceous sandstone which terminates this division. This rock on Rothwell-Haigh is near forty yards in thickness, separated by thin partings of shale; the upper part, when recently quarried, is soft, and cuts readily into troughs, ridge-stones, &c. It contains remains of Calamites.

In the strata above the Haigh-Moor coal, ferns are more numerous than in the measures of the lower seams, and here, for the first time, the remains of syringodendra occur. This remark is made after the examination of many hundred fossil plants; amongst them I have not met with any specimen of Syringodendron from the beds below the Haigh-Moor seam, whilst in those above it is by much the most common fossil.*

* In the Museum of the Leeds Philosophical and Literary Society is a fluted stem, about thirteen inches in length and without joints, from the millstone grit of Bramley-Fall; it has, however, none of the peculiar markings of the syringodendra, and probably may be the lower part of a gigantic reed.

In the bed of bituminous shale which immediately covers the Haigh-Moor coal, are a great number of fossil plants; they are a few Lepidodendra, and a great number and variety of Filicites, Osmunda *gigantea*, two or three varieties of Pteris, the leaves of one of which are long and narrow, Asplenium, Calamites *pseudobambusia*, *nodosa*, and *rotularia*; the remains of large leaves are not uncommon. On the shale both of the Waterloo and the Lofthouse collieries are found some very minute microscopic shells, which have the appearance of Helices. It was from the measures above this coal that the second fossil animal described in the paper before mentioned, as sent to the Geological Society, was discovered.*

In the beds between the Haigh-Moor coal and the forty yards seam many fossils occur; they are principally what have been before described. The roof of the forty yards coal abounds with the most beautiful syringodendra. I have measured specimens fourteen feet in length without apparent contraction in width; connected with these are fine specimens of Calamites *pseudobambusia*, and in the upper part of the bed is the mass of *Uniones* before noticed.

The Haigh-Moor coal leaves the magnesian limestone at Garforth, where it is worked; its basset passes in a straight line through Austhorpe to Halton, where both the Main and Little coal are worked by shallow pits. To the west its course is terminated by fault No. ..... On the south of

* *Vide* page 154.

Halton, at Waterloo, the colliery recently opened on the estate of the Marchioness of Hertford, at Temple-Newsam, the coal is found of excellent quality, and of great thickness; this increase is occasioned by the partings of coal noticed as occurring in the floor at Middleton, being here united with the Main coal. At Waterloo colliery the Little coal is forty-two yards above the Main coal, and it will be seen, on comparing the Middleton and Waterloo sections, that at the latter colliery many of the coals sunk through in the former are wanting, and in this case there can be no doubt of the identity of the beds, the two collieries being connected by underground workings.

On the south bank of the Aire are the extensive collieries of Rothwell-Haigh and Middleton, in which the Haigh-Moor coal has been worked for near a century. The coal continues to be thrown out by fault No. ..... to near Beeston, where it bassets, and is again thrown out to the west of Middleton-Hall. These collieries are terminated to the south by fault No. ....., which is a dislocation of great magnitude, elevating the measures to the south of it one hundred and twenty yards. To the south of fault No. ....., the Haigh-Moor coal bassets near Thorp-Hall, and continues in a south-westerly direction on the west of Ardsley and Hanging-Heaton to near Dewsbury. It may be traced afterwards south-east, on the summit of the ridge to the north of the Calder, to near Horbury, where it crosses the river.

Within this line are the collieries of Lofthouse,

Ardsley, Haigh-Moor, Wakefield Outwood, and Alverthorpe.

Upon Wakefield Outwood the forty yards coal of Middleton becomes divided, and in its course eastward forms the Warren-House coal, which is worked near Stanley.

In the different parts of its course the Haigh-Moor coal is of very various quality, always a good coal, but differing in its "bact" as it is called by the colliers. At Middleton it is moderately hard, and breaks into nearly square or cuboidal pieces, whilst at Lofthouse it is softer and comes to the surface in masses, very long compared with their breadth.

The thick argillaceous sandstone passes from under the magnesian limestone between Garforth and Kippax; it has been bored through in the valley of the Aire at Swillington, and is seen on the south bank of that river at Rothwell; upon Rothwell-Haigh it is extensively quarried as a freestone for troughs, &c. From Rothwell-Haigh it may be traced west of Thorp-Hall, and again to the south upon Wakefield Outwood.*

* The manuscript here terminates abruptly, the premature death of the author having prevented him completing the sixth and seventh divisions of the Coalfield alluded to at page 138.

APPENDIX TO MR. GEORGE'S PAPER.

The following records of Borings in various parts of the Coalfield were found amongst the papers of Mr. George, and are here inserted for the purpose of illustrating the preceding observations, and of assisting those who may in future be disposed to carry on the investigation of the Yorkshire Coalfield.

EMLEY-MOOR.

	Yds.	Ft.	In.
Soil and clay,	6	0	6
Grey stone,	0	1	7
Soft blue metal,	1	0	3
Stone,	0	0	6
Grey metal,	0	1	3
Stone,	1	0	0
Metal,	0	0	11
Grey stone,	1	0	6
Blue metal,	1	0	2
Stone,	0	0	6
Black shale,	0	0	2
Coal—Stone coal, 2ft. ... „ Black top coal, 6in.	0	2	6
Blue metal,	0	1	7
Grey metal,	0	1	2
Hard stone bind,	2	2	0
Metal and bind,	6	1	3
Stone,	0	0	8
Stone bind,	1	2	9
Carried forward,	25	0	3

	Yds.	Ft.	In.
Brought forward,	25	0	3
Metal, (blue,)	1	2	0
Roof or shale,	0	0	4
Coal,	0	1	8
Blue metal,	2	0	6
Grey bind,	3	0	10
Stone,	1	0	3
Blue metal,	0	0	9
Soft blue metal,	2	0	0
Grey bind,	0	1	6
Black shale,	0	0	8
Stone,	0	2	0
Stone bind,	5	1	5
Strong blue metal,	5	0	4
Stone,	1	1	0
Strong stone bind,	2	1	0
Metal, commonly called white earth,	1	0	0
Black shale,	0	1	6
Coal, *(variable,)*	1	2	10
	55	0	10

GRANGE-MOOR,

IN THE PARISH OF KIRKHEATON.

	Yds.	Ft.	In.
Clay and soil,	5	0	0
Brown shale,	2	0	0
Stone bind,	3	2	3
Grey stone,	3	0	0
Blue metal,	4	0	3
Coal,	0	2	0
Blue metal,	2	1	4
Coal,	0	0	6
Grey metal,	2	2	6
Stone bind,	13	1	0
Coal,	0	2	2
Blue stone bind,	10	0	0
Rust,	1	0	0
Blue stone,	8	0	0
Black shale,	0	0	9
Coal,	0	0	6
Roof shale,	0	0	6
Coal,	0	0	3
Roof,	0	0	6
Main coal,	1	0	2
	58	2	8

ASTLEY COLLIERY,

NEAR THE ENGINE PIT.

	Yds.	Ft.	In.
Quicksand,	3	0	0
Brown sandstone,	2	1	0
Blue bind,	1	0	0
Coal,	0	2	9
Black shale,	0	1	4
Coal,	0	1	8
Grey stone,	0	0	8
Blue bind,	1	1	7
Carried forward,	10	0	0

	Yds.	Ft.	In.
Brought forward,	10	0	0
White stone,	3	1	7
Coal,	0	0	4
Blue bind,	3	2	4
Black shale,	2	1	11
Blue bind,	13	1	6
Black shale,	2	2	6
Blue bind,	8	2	11
Stone bind,	8	0	11
White earth,	3	0	4
Coal,	1	2	6
Grey stone,	3	1	6
Coal,	1	1	7
Black shale,	1	2	3
Blue bind,	5	0	2
White earth,	1	0	7
Black shale,	1	1	5
Grey stone,	0	0	6
White stone,	1	0	3
Blue bind,	6	1	3
White stone	2	2	4
Calliard,	0	2	6
Blue bind,	7	0	0
White earth,	0	2	6
Black shale,	0	2	1
White earth,	7	0	1
Coal,	0	1	6
Spavon earth,	0	0	3
Blue bind,	3	2	9
Calliard,	0	1	2
White stone,	0	0	9
Blue bind,	4	0	3
White stone,	2	2	7
Blue bind,	0	2	9
White stone,	9	0	0
Grey stone,	1	0	1
Black shale,	0	1	3
Coal, bored into, (real thickness not known.)	0	0	11
	123	2	1

PIT SUNK IN THE

NEW COLLIERY AT ASTLEY,

NEAR FLACKENLEY BRIDGE.

	Yds.	Ft.	In.
Earth and yellow clay, ...	1	2	0
Blue clay, ...	1	1	5
Black shale,.....	0	1	3
Grey stone,.....	0	2	0
Dark blue bind, ...	0	1	2
Blue bind, ...	6	0	0
Sandstone, (blue,)	1	1	3
Calliard, ...	1	2	9
Sandstone, ...	0	1	5½
Dark blue bind, ...	12	2	8
Loft blue bind, ...	0	0	6
Black shale,.....	1	1	11
Grey stone,.....	0	1	9
Blue bind, ...	5	0	1
White sandstone, ...	0	0	5
Dark blue bind, ...	3	1	2
Sandstone, ...	2	1	0
Black shale,.....	0	1	0
Grey stone,.....	1	0	8
Soft blue bind, ...	0	2	0½
Dark blue bind, ...	8	0	2
Black shale,.....	2	1	10
Coal, ...	1	0	5
Black shale,.....	0	2	1
Coal, ...	0	2	1
Soft blue bind, ...	0	0	4
Hard sandstone,.....	0	1	4
Soft blue bind, ...	0	0	6
Strong blue bind, ...	3	2	0
Hard blue stone,.....	0	0	7
Dark blue bind, ...	1	1	7
Black bind,.....	3	2	1
Grey bind, ...	0	2	3
Coal, ...	0	1	4
Blue bind, ...	6	0	9
Carried forward,.....	73	0	10

	Yds.	Ft.	In.
Brought forward,.....	73	0	10
Black shale,.....	0	1	1
Blue bind, ...	5	0	9
Brown stone, ...	0	1	1
Blue bind, ...	7	1	2
Black shale,.....	0	1	3
Coal, ...	0	0	9
Black shale,.....	0	1	0
Coal, ...	0	2	11
Grey stone,.....	1	0	3
Blue bind, ...	2	0	9
Blue dark bind, ...	3	0	6
Black shale,.....	0	1	8
Coal, ...	1	0	6
Black shale,.....	0	1	0
Coal, ...	1	1	0
Grey stone,.....	1	1	2
	99	2	8

BORING TO THE

HAIGH-MOOR COAL,

AT NEW PARK, NORTH OF ALVERTHORPE, NEAR WAKEFIELD.

	Yds.	Ft.	In.
Earth and sand,.....	4	1	6
White earth, ...	1	0	0
Stone,.....	1	2	4
White earth, ...	6	2	6
Grey bind,.....	4	2	8
Stone,.....	10	2	9
White earth, ...	7	0	1
Black earth, ...	0	0	10
Coal, ...	0	0	4
Spavon, ...	1	1	9
Grey bind, ...	1	0	0
Stone, ...	2	2	2
Carried forward,.....	42	1	11

	Yds.	Ft.	In.
Brought forward,.....	42	1	11
Calliard, ...	0	1	1
Stone, ...	2	1	4
White earth, ...	5	1	0
Blue bind, ...	1	1	1
Black shale,.....	0	1	9
Spavon earth,.....	0	0	11
White earth, ...	1	1	0
Black shale,.....	1	0	3
White earth, ...	5	0	10
Black earth, ...	0	0	11
Coal smit, ...	0	0	1
Black earth, ...	0	2	0
Coal, ...	0	1	4
Black earth, ...	2	1	4
Black shale,.....	0	0	5
*Coal, ...	0	2	7
Earth,.....	0	0	3
Coal, ...	0	1	1
Spavon earth,.....	0	1	0
White earth, ...	0	2	3
Coal and drub, ...	0	0	6
Spavon, ...	1	0	1
White earth, ...	5	2	8
Grey bind, ...	2	0	11
Stone, ...	0	2	9
Stone bind,.....	5	0	4
White earth, ...	0	2	1
Black shale,.....	0	1	0
Black earth, ...	0	0	5
†Coal, ...	0	1	7
Spavon, ...	0	1	0
White earth, ...	4	2	7
Black earth, ...	0	0	5
Spavon, ...	1	0	0
Stone, ...	2	1	9
White earth, ...	2	0	5
Stone, ...	1	2	0
Calliard, ...	0	2	11
Carried forward,.....	97	2	10

	Yds.	Ft.	In.
Brought forward,.....	97	2	10
Stone,.....	1	1	3
Blue bind, ...	1	1	7
Black shale,.....	0	0	10
Stone bind,.....	2	0	6
Blue bind, ...	3	0	3
Coal, ...	0	0	7
Spavon earth,.....	0	0	10
Spavon stone,.....	2	1	1
White earth, ...	3	1	1
Blue bind, ...	0	1	9
Black shale, ...	0	1	4
Coal, ...	0	2	0
Spavon earth, ...	0	2	9
White earth, ...	3	0	9
Black shale, (full of shells,)	0	1	1
Grey bind, ...	1	1	5
Black shale,.....	0	1	1
Grey bind, ...	2	0	4
Calliard, ...	0	1	0
Grey stone,.....	2	2	4
Grey bind, ...	3	0	10
White earth, ...	1	0	1
Coal, (Haigh-Moor,)	1	0	4
	131	0	11

* Wakefield top coal, or Gawthorpe hard coal, is the same as the Middleton 40 yards.

† Is got below East Ardsley, at Kirkhamgate, on Wakefield Outwood, and at Woodhouse-Lane, near Ardsley, is one yard thick, is the same as the Middleton little coal.

BORINGS NEAR

STANLEY WORKHOUSE.

Earth and clay, ...	2	0	7
Marl, ...	1	2	8
Carried forward,.....	4	0	3

	Yds.	Ft.	In.
Brought forward,.....	4	0	3
Grey bind, ...	3	2	6
Stone bind, ...	4	0	10
Stone, ...	0	1	3
Stone bind,.....	5	0	2
Grey stone,.....	3	2	8
Stone bind,.....	5	0	1
Grey bind, ...	5	1	5
Stone bind,.....	4	1	0
Stone, ...	1	1	3
Grey bind, ...	2	0	3
Blue bind, ...	1	0	10
Coal, ...	0	0	10
Spavon, ...	1	0	4
White earth, ...	2	1	0
Stone, ...	1	0	0
White earth, ...	1	2	2
Stone, ...	0	1	6
Stone bind,.....	3	0	11
Stone, ...	0	2	4
White earth, ...	4	0	4
Black shale,.....	2	0	2
Coal, ...	0	1	10
Spavon earth,.....	1	2	6
Stone,.....	0	1	0
Stone bind,.....	2	2	9
Grey bind, ...	2	0	5
White earth, ...	3	2	3
Coal, ...	0	1	1
Spavon earth,.....	1	0	1
Stone,.....	0	2	0
Grey bind, ...	1	0	0
Calliard, ...	0	1	2
Stone,.....	0	2	0
Grey bind, ...	1	1	7
White earth, ...	6	1	10
Black shale, ...	6	0	7
Stone coal and black coal,	1	0	5
Spavon, ...	0	2	0
Carried forward,.....	90	0	7

	Yds.	Ft.	In.
Brought forward,.....	90	0	7
Stone, ...	4	1	4
Stone bind, ...	1	2	3
White earth,.....	2	0	0
Grey bind, ...	3	2	10
White earth,.....	7	1	2
Black earth, ...	0	1	2
Coal, ...	0	0	4
Earth, ...	0	0	5
Coal, ...	0	1	1½
Earth, ...	0	0	11
Coal, ...	0	2	4
Earth, ...	0	0	6
Main coal,.....	1	0	5
	113	0	4½

SECTION IN THE

VALLEY SOUTH-EAST OF ARDSLEY COMMON,

AND BEYOND THE OUTBREAK OF THE HAIGH-MOOR COAL.

Earth and clay, ...	1	1	6
Marl, ...	0	1	6
Rag and stone, ...	7	0	5
Strong white stone,.....	2	2	6
White earth, ...	0	1	9
Strong white stone,.....	7	1	0
Bind, ...	0	2	0
Stone,.....	2	2	7
Dark metal, ...	0	1	5
Stone,.....	0	1	4
White earth, ...	0	1	2
White stone, ...	8	1	11
Black earth,.....	0	2	2
Carried forward,.....	34	0	3

	Yds.	Ft.	In.
Brought forward,.....	34	0	3
White earth, ...	1	2	7
Grey stone bind, ...	0	1	8
Dark metal, ...	0	0	8
White earth, ...	1	2	8
Black drub,.....	2	2	11
Spavon earth,.....	0	2	8
Strong stone bind,.....	3	1	8
Coal and shale, ...	0	1	4
Spavon earth,.....	0	1	8
Spavon stone,.....	0	2	1
Blue bind, ...	0	1	10
Grey bind, ...	2	1	4
Black earth, ...	0	0	11
Spavon earth,.....	0	0	8
Bind, ...	0	1	7
Strong stone bind,.....	4	1	11
Dark metal, with ironstone, ...	1	1	10
Grey bind, ...	0	2	0
Black shale,.....	0	1	7
Coal, ...	0	2	6
Spavon, ...	0	1	1
Spavon stone,.....	1	0	11
Bind, ...	0	2	0
Strong stone bind, ...	5	0	5
Black shale and coal,.....	0	1	0
Spavon, ...	0	1	1
Bind, ...	0	1	10
Stone with calliard, ...	2	0	3
Dark bind, ...	0	2	0
Strong black shale,.....	4	0	9
Stone coal, ...	0	0	9
Coal, ...	0	2	10
	77	0	3

MEASURES THROUGH THE HAIGHMOOR SEAMS TO THE

BEESTON SEAMS AT GARFORTH.

	Yds.	Ft.	In.
Earth and clay, ...	2	0	9
Strong sandstone, ...	1	2	6
Blue metal,.....	11	1	1
Coal, ...	0	2	3
Strong grey stone,.....	6	1	7
Coal, ...	0	1	0
Blue metal,.....	4	1	2
Calliard, ...	0	0	10
Dark blue metal, ...	0	2	5
Strong brown stone, ...	3	1	0
Dark blue metal, ...	5	0	4
Firth field coal, ...	1	0	6
Blue metal,.....	0	1	3
Coal, ...	0	0	10
Dark blue metal, ...	5	1	2
Coal, ...	0	2	9
Dark blue metal, ...	5	0	5
Coal, ...	0	2	1
Black shale, ...	0	0	5
Coal, (hard band,)	1	0	6
Strong white stone mixed with calliard, ...	15	0	8
Metal mixed with stone,	3	2	0
White stone with calliard,	8	1	0
Metal mixed with stone,...	3	1	0
Black shale,.....	0	0	7
High main coal,.....	1	2	0
Dark soft metal,.....	2	2	3
Strong sandstone, ...	11	1	9
Blue sand metal,.....	2	1	2
Sandstone, ...	0	2	6
Blue sand metal,.....	2	1	9
Sand stone,.....	3	0	7
Blue sand metal,.....	1	0	5
Carried forward,... ..	109	0	6

	Yds.	Ft.	In.
Brought forward,.....	109	0	6
Sandstone mixed with calliard, ...	9	0	8
Blue sand metal,.....	0	1	2
Sandstone, ...	2	1	0
Dark sand metal, ...	0	1	10
Coal, ...	0	2	6
Dark soft metal,.....	0	1	2
Metal mixed with stone,	5	1	8
Grey stone,.....	8	0	0
Blue metal, ...	7	1	2
Coal, ...	0	1	0
Dark soft metal,.....	0	2	4
Blue metal mixed with stone, ...	7	1	0
Dark blue metal, ...	2	0	3
Dark blue metal mixed with stone, ...	3	0	5
Grey stone with calliard,	3	0	6
Metal with stone, ...	2	0	6
Dark grey stone, ...	1	1	3
White stone, ...	2	2	10
Blue metal,.....	3	1	0
Dark blue metal, ...	7	0	5
Black shale,.....	0	0	10
Low main coal, ...	1	2	0
	179	2	0

BORING TO A COAL SUPPOSED TO BE THE HAIGH-MOOR, NEAR

SWILLINGTON BRIDGE.

	Yds.	Ft.	In.
No account of.....	64	0	0
Blue bind, ...	1	0	0
Black shale,.....	0	0	4
Coal, ...	0	0	10
Spavon stone,.....	0	1	4
Carried forward,.....	65	2	6

	Yds.	Ft.	In.
Brought forward,.....	65	2	6
Blue bind, ...	1	1	9
Blue bind, ...	0	1	9
Black shale,.....	0	0	9
Coal, ...	0	1	0
White earth, ...	0	0	3
Black shale,.....	0	1	4
Coal, ...	0	1	8
White earth, ...	0	1	0
Coal, ...	0	0	3
Spavon stone,.....	0	1	8
Blue and stone bind, ...	1	2	5
White stone, ...	1	0	8
Blue bind, ...	7	2	2
Black shale,.....	0	0	4
*Coal,.....	0	2	4
Spavon earth,.....	1	0	1
Coal, ...	0	2	8
Black shale,.....	0	1	4
Spavon earth,.....	1	2	0
Brown metal, ...	2	2	6
White earth, ...	3	2	11
Black shale,.....	0	2	1
White shale, ...	0	2	11
Black shale,.....	0	0	11
Grey stone,.....	0	1	5
Blue bind, ...	6	0	0
White earth, ...	1	1	8
Black shale,.....	0	0	8
Coal, ...	0	0	6
Black shale,.....	3	1	1
†Coal,.....	1	0	4
Grey stone,.....	0	0	5
Spavon stone,.....	1	2	10
Blue bind with calliard, ...	19	2	2
Coal, ...	0	1	1
Spavon earth,.....	0	0	7
Blue bind, ...	10	0	10
White earth, ...	2	1	1
Carried forward,.....	142	2	11

	Yds.	Ft.	In.
Brought forward,.....	142	2	11
Black shale,.....	0	1	3
Iron stone, ...	0	0	6
White earth, ...	0	1	3
Black shale,.....	0	0	5
Coal, ...	0	1	0
Black shale,.....	0	2	0
White earth, ...	1	1	1
Black shale,.....	0	0	4
‡Coal,.....	1	0	9
	147	2	6

* 40 yards coal, Middleton.
† Little coal.
‡ Haigh-Moor.

MEASURES TO THE HAIGH-MOOR COAL

AT

WATERLOO COLLIERY,

NEAR LEEDS.

	Yds.	Ft.	In.
Earth,.....	2	0	0
Sand and gravel, ...	5	2	0
Blue metal,.....	1	1	1
Black shale,.....	1	0	0
Grey sandstone,.....	0	2	7
Blue bind, ...	1	2	10
Blue sandstone, ...	1	0	4
White earth, ...	1	2	0
Black shale,.....	0	0	11
Coal smit, ...	0	0	11
Spavon, ...	0	1	7
Stone bind,.....	2	1	6
Strong stone, ...	1	0	4
Blue bind, ...	0	1	5
Black shale,.....	0	0	5
Strong stone, ...	1	1	8
Carried forward,.....	22	1	7

	Yds.	Ft.	In.
Brought forward,.....	22	1	7
Stone bind,.....	3	2	1
White earth, ...	1	1	7
*Coal, ...	1	0	0
Spavon earth,.....	1	0	6
Blue bind, ...	3	0	6
Dark stone,.....	0	2	5
Blue bind, ...	1	1	2
Blue sandstone, ...	1	0	5
Calliard, ...	0	0	9
Strong stone, ...	2	2	11
White earth, ...	2	0	9
Shale, ...	0	0	9
Spavon, ...	1	0	2
Strong stone, ...	3	2	6
Black shale,.....	0	1	0
Spavon, ...	0	0	6
Strong sandstone, ...	1	2	11
Stone bind,..... ..	3	2	5
Stone and calliard,.....	0	1	2
White earth, ...	1	2	0
Black drub,.....	0	1	1
Black shale,.....	0	0	11
Coal, ...	0	1	0
Spavon, ...	0	2	1
Blue bind, ...	0	2	11
Blue sandstone, ...	2	0	5
Stone bind,.....	1	0	6
Strong stone, ...	0	1	0
Calliard, ...	0	2	7
Strong sandstone, ...	2	1	1
Stone bind,.....	1	2	1
Blue sandstone, ...	3	0	0
White earth, ...	3	1	10
Black shale,.....	0	0	7
†Good coal,.....	1	2	3
	75	0	5

* Middleton little coal.
† Haigh-Moor seam. At 10 yards above the Haigh-Moor seam is a muscle band.

MEASURES TO THE FIRST WEST PIT IN

MIDDLETON COLLIERY,

EXTENDING TO THE LITTLE COAL.

1819.

	Yds.	Ft.	In.
Earth and gravel,	3	0	0
Clay,	1	1	0
Blue argillaceous sandstone,	21	0	0
Brown metal,	5	0	0
Blue metal with sandstone balls and girdles,	7	0	0
Dark metal,	2	0	0
Coal, got formerly for the iron-stone above it,	0	1	6
Grey metal,	3	1	6
Dark grey metal,	0	1	6
Coal,	0	0	6
Dark blue metal with iron-stone,	10	0	0
Coal,	0	2	2
Dark grey metal,	1	1	6
Light grey metal and metal stone,	2	2	0
Strong blue metal,	3	1	0
Strong blue stone,	1	0	0
Dark metal,	0	2	9
Coal,	0	0	10
Soft grey metal,	1	1	6
Grey metal and grey metal stone,	2	2	3
Calliard and light grey stone,	1	2	9
Strong brown stone mixed with calliard,	0	1	0
Dark metal,	3	1	5
Coal, } 40 yds. coal,	0	0	5
Grey metal, } 40 yds. coal,	0	0	9
Coal, } 40 yds. coal,	0	2	8
Carried forward,	75	2	0

	Yds.	Ft.	In.
Brought forward,	75	2	0
Grey and blue metal,	7	0	2
Dark metal,	0	2	2
Two smits of coal with six inches of grey metal betwixt,	0	0	11
Grey metal and grey metal stone,	2	0	0
Light blue metal,	1	0	4
Coal,	0	0	10
Soft grey metal,	1	0	9
Dark metal,	1	0	0
Coal,	0	2	6
Dark grey metal,	1	2	0
Strong grey stone,	1	2	0
Calliard,	1	1	0
Strong grey metal,	0	2	8
Black shale,	0	2	2
Brown metal coal,	0	1	10
Dark grey metal,	0	2	10
Strong blue stone,	2	0	0
Strong blue metal,	2	2	0
Second brown metal coal,	0	1	6
Brown metal,	3	2	0
Strong grey metal,	8	0	0
Little coal,	1	0	3
	115	2	11

MEASURES TO THE HAIGH-MOOR COAL AT THE FANNY PIT IN

MIDDLETON COLLIERY.

	Yds.	Ft.	In.
Earth and clay,	2	0	0
Blue argillaceous sandstone,	25	0	0
Blue metal,	7	0	0
Carried forward,	34	0	0

	Yds.	Ft.	In.
Brought forward,.....	34	0	0
Black drub,.....	3	0	0
Strong stone bind, ...	13	0	0
Ravin or stone coal, ...	0	0	6
Black coal, ...	0	1	0
Spavon, ...	1	0	0
Stone bind,.....	11	0	0
Stone and calliard, ...	4	0	0
Strong black shale, (containing unio subconstrictus,)	4	0	0
The 40 yards coal,.....	1	0	0
Spavon earth,.....	0	1	6
Spavon stone,.....	2	0	0
Stone bind,.....	12	0	0
Coal, ...	0	1	6
Spavon earth,.....	0	1	6
Spavon stone,.....	1	1	0
Stone bind,.....	5	0	0
Brown metal coal, ...	0	1	9
Spavon earth,.....	0	1	0
Spavon stone,.....	2	0	0
Bind, ...	3	2	0
Brown metal, ...	4	0	0
Stone bind,.....	7	0	0
Little coal, ...	1	0	0
Spavon earth,.....	0	1	6
Spavon stone,.....	2	0	0
Stone bind,.....	4	0	0
Coal, ...	0	0	9
Strong stone bind, stone, and calliard, ...	20	0	0
Bind, ...	4	0	0
Black shale,.....	0	0	9
Haigh-Moor coal, ...	1	1	6
	144	1	3

MEASURES BELOW THE HAIGH-MOOR SEAM, AT

MIDDLETON, NEAR LEEDS.

(A Boring.)

	Yds.	Ft.	In.
Loose chanelly coal, ...	0	2	0
Grey metal,.....	0	1	0
Dark scarred metal with thin seams of coal and sulphur, ...	1	0	6
Grey metal,.....	0	1	6
Grey metal stone, ...	6	0	4
Coal with sulphur, ...	0	2	10
Grey metal with ironstone,	2	0	0
Strong grey post, ...	5	0	0
Grey metal and metal stone, ...	2	0	10
Grey metal and metal stone, with ironstone,...	7	1	8
Grey metal with ironstone,	4	0	0
Coal, ...	0	1	1
Grey metal with sulphur and girdles, ...	3	1	0
Calliard and white post, with water, ...	0	2	0
Strong thready white post,	2	2	0
Grey and dark grey metal, with ironstone and girdles, ...	7	0	0
Strong white grey post with calliard, ...	3	1	6
Grey metal and metal stone, with ironstone, sulphur, and some beds of post, ...	17	1	7
Black slaty metal, with sulphur, ...	0	2	0
Grey metal stone, with hard ironstone girdles,	3	0	0
Carried forward,.....	69	0	10

	Yds.	Ft.	In.
Brought forward,.....	69	0	10
Calliard, ...	0	1	8
White post, with partings of metal stone, ...	4	0	0
Calliard, ...	0	0	8
White post with partings,	1	1	0
Dark grey metal, and black metal, and metal stone, with sulphur and hard girdles, ...	4	0	0
Strong white post, with calliard, ...	4	2	8
Black and grey metal, with some thin girdles at top, ...	4	0	0
Grey metal stone, ...	2	0	7
(BEESTON SEAM.)			
Hard coal, ...	0	2	4
Grey metal,.....	0	0	5
Coal, ...	0	0	7
Hard band,.....	0	0	2
Coal, ...	0	0	6
Dark grey metal, with a small mixture of coal,...	0	0	2
Coal, (soft,)	0	0	4
Grey and dark grey metal, with several bands of coal,.....	0	1	6
Coal, ...	0	1	4
Grey metal, ...	0	2	0
Strong coal, ...	0	1	6
Blue grey metal,.....	1	0	0
(Left off in a strong grey post, bored into it.)			
	95	0	3

TO THE MAIN COAL AT

FLOCKTON.

	Yds.	Ft.	In.
Soil and clay, ...	1	0	0
Grey metal, ...	1	1	9
Grey stone, with brown seams, ...	0	1	7½
Grey stone, with clay seams, ...	5	1	6
Grey metal, with brown girdles, ...	3	2	3
Grey stone, ...	0	1	4½
Blue metal, ...	3	0	11
Strong stone bind, ...	3	2	10½
Blue metal, ...	0	1	9½
Coal, ...	0	0	7
Blue metal, ...	1	0	7
Coal, ...	0	0	3
Grey stone, ...	0	1	3
Stone bind, ...	0	1	3½
Hard blue stone, (one lift,)	0	0	4½
Blue stone, ...	0	0	6
Blue stone bind, ...	0	2	0
Hard blue stone bind, with girdles, ...	2	1	8½
Very soft blue metal, ...	0	0	4
Blue metal, ...	4	1	11
Stone bind and blue metal,.....	0	2	2
Ironstone,.....	0	0	4
Blue metal, with ironstone balls, ...	0	2	0
Ironstone,.....	0	0	2½
Blue metal, with ironstone balls, ...	0	2	4½
Ironstone,.....	0	0	2
Blue soft metal, ...	2	0	5½
Ironstone,.....	0	0	1½
Blue soft metal, ...	1	0	10½
Carried forward,.....	37	0	7

	Yds.	Ft.	In.
Brought forward,.....	37	0	7
Blue hard metal,.....	0	1	0
Very soft metal, ...	1	0	0
Blue metal, with ironstone balls, ...	2	2	4
Black shale,.....	1	1	10
White soft metal, ...	0	2	9
Coal, ...	0	2	2
Seat earth, ...	0	1	0
Grey stone,.....	2	0	0
Strong stone bind, ...	3	0	0
Hard metal and stone bind	0	2	0
Black shale,....	0	1	0
Grey stone,.....	0	1	0
Metal, ...	0	0	4
Ironstone, ...	0	0	1
Metal, with iron balls,.....	1	0	0
Ironstone, ...	0	0	2
Black and brown metal, with sometimes one inch of ironstone, ...	0	2	0
Ironstone, ...	0	0	3
Metal, with ironstone balls of large size, ...	1	0	2
Soft blue metal, ...	0	0	3
Grey and blue stone, ...	1	0	0
Stone bind,.....	3	1	6
Hard stone, (calliard,) ...	0	1	0
Stone bind,.....	0	2	0
White earth, ...	2	1	6
Black shale,.....	1	0	2
Ironstone, ...	0	0	4
Post, ...	0	0	8
Coal, with hard pyritous substances, ...	0	0	4
Coal, ...	0	1	4
Dirt, ...	0	1	4
Coal, ...	0	1	2
Soft blue metal, ...	0	1	0
Carried forward,.....	65	1	3

	Yds.	Ft.	In.
Brought forward,.....	65	1	3
Stone, ...	0	0	2
Blue metal,.....	0	0	3
Hard grey stone, ...	0	2	0
Strong bind stone, ...	4	0	0
Stone, (calliard 1ft. 6in.)	1	1	0
Hard blue metal, ...	5	0	0
Black shale, ...	0	2	3
Strong stone bind,.....	4	0	0
Black post, ...	0	0	9
Coal, ...	0	1	8
Blue metal,.....	7	2	0
Stone in lifts, ...	6	1	0
Stone bind,.....	0	1	0
Grey stone in lifts, 2ft. 3in. thick, ...	2	1	6
Stone bind,.....	4	1	6
Metal,.....	0	1	6
Stone and metal in lifts,	2	1	6
Stone bind,.....	0	1	5
Stone,.....	0	1	0
Stone bind,.....	0	1	10
Stone, in one lift, ...	0	1	9
Stone bind,.....	0	2	0
Stone, 5in. next coal blue,	4	0	0
Coal, ...	0	1	5
Blue metal,.....	0	2	6
Blue stone, ...	2	1	6
Blue metal,.....	5	1	6
Blue metal, with ironstone balls, ...	0	1	9
Blue metal, with ironstone flaws, 4in. thick	2	0	0
Blue metal,.....	1	0	0
Black shale,.....	1	0	0
Coal, ...	0	0	2
Strong blue metal, ...	1	0	2
Blue stone, ...	1	1	6
Stone bind,.....	1	1	6
Carried forward,.....131	0	4	

	Yds.	Ft.	In.
Brought forward,	131	0	4
Stone,	2	1	6
Black and blue metal,	2	0	0
Coal,	0	2	9
Blue metal,	0	1	0
Stone,	1	0	0
Stone bind in regular lifts,	10	0	0
Blue metal,	0	1	0
Stone,	0	1	2
Blue metal,	1	1	0
Stone,	0	1	2
Blue metal,	0	1	0
Stone bind,	3	0	4
Grey stone bind,	8	2	0
Coal,	1	0	6
	163	1	9

MEASURES SUNK THROUGH IN THE WOOD PIT AT

BEESTON PARK COLLIERY.

1813 and 1814.

	Yds.	Ft.	In.
Earth and clay,	1	0	9
Coal,	0	0	6
Spavon,	0	2	6
Blue bind,	2	1	6
Grey bind,	1	0	2
Stone bind,	4	1	6
Ironstone,	0	0	6
Blue and grey bind,	2	2	5
Ironstone,	0	0	4
Blue bind,	4	1	2
Coal, Middleton little coal,	0	2	10
Spavon,	0	1	7
Coal,	0	0	7
Spavon,	0	2	8
Carried forward,	20	1	0

	Yds.	Ft.	In.
Brought forward,	20	1	0
Blue bind,	3	0	11
Black shale,	0	1	9
Coal,	0	0	7
Grey bind,	10	1	10½
Stone, with calliard,	3	0	7½
Stone bind,	5	2	2
Blue bind,	3	0	4
Middleton Main Coal, Haigh-Moor,	1	1	5
Black earth and coal,	2	0	7
Spavon,	0	2	8½
Stone and blue bind,	6	1	2
Black shale,	0	0	4
Coal, (Middleton, eleven yards,)	0	2	10
Spavon,	1	1	9
Grey bind,	3	0	0
Black shale,	0	1	2
Spavon stone and calliard,	2	0	2
Grey bind,	6	0	6
Black shale,	0	1	0
Coal,	0	0	3
Spavon,	0	2	5
Bind,	3	2	8
Coal,	0	1	2
Spavon,	2	1	11
Blue bind,	4	0	9
Stone bind, with calliard,	5	0	10
Blue bind,	6	0	2½
Black shale,	1	1	4
Spavon,	1	0	5
Calliard,	0	2	0
Blue bind,	4	2	9
Stone bind,	2	2	5
Stone,	1	2	6
Coal,	0	0	3
Spavon,	1	2	10
Stone,	1	0	11
Carried forward,	112	0	6

	Yds.	Ft.	In.
Brought forward, ...	112	0	6
Stone bind, ...	2	0	3
Blue bind,.....	2	1	11
Black shale, ...	0	1	6
Spavon, ...	1	0	1
Main stone, ...	5	1	6
Shale, ...	2	2	5
Blue bind,.....	3	0	5
Stone, ...	0	2	0
Blue bind,.....	2	1	5
Shale, ...	3	1	3
White earth,.....	1	0	6
Black shale, ...	0	0	5
(BEESTON SEAM.)			
Coal, ...	0	2	3
Parting,.....	0	0	3
Coal, ...	0	1	4
Parting, ...	0	0	2
Coal, (inferior,)	0	0	7
Parting, ...	0	0	2
Coal, (inferior,)	0	0	6
Parting, ...	0	0	2
Coal, ...	0	0	10
Parting, ...	0	0	1
Coal, ...	0	0	7
Parting,.....	0	0	0½
Coal,.....	0	0	9
	140	0	10½

MEASURES IN A BORING BELOW THE

HAIGH-MOOR COAL,

AT SIMPSON'S SPRING, NEAR EAST ARDSLEY.

	Yds.	Ft.	In.
Spavon earth, ...	2	1	9
Coal, (inferior,)	0	0	8
Carried forward,.....	2	2	5

	Yds.	Ft.	In.
Brought forward,.....	2	2	5
Dark soap metal, ...	0	0	10
Coal, (inferior,)	0	1	10
Dark cold earth,.....	0	1	5
Blue stone bind,.....	1	0	11
Black shale, with coal,.....	0	0	4
Blue and grey stone bind,	8	1	2
Coal, (hard,)	0	0	9
Dark cold earth,.....	0	0	5
Grey stone bind,.....	2	1	0
Blue slaty drub, with ironstone balls, ...	4	2	7
Black shale,.....	0	1	11
Coal, (inferior,)	0	0	7
Spavon stone,.....	1	0	10
Black shale,.....	0	0	11
Blue stone bind, with sulphur, ...	10	2	0
Dark earth,.....	0	1	0
Blue stone bind,.....	2	2	6
Blue grey stone, with ironstone, ...	10	0	11
Blue soapy metal, ...	9	0	11
Calliard, ...	1	0	0
Black earth, with coal pipes, ...	1	0	0
Blue stone bind,.....	1	0	6
Blue gritty stone, with ironstones, ...	4	1	1
Blue soapy metal, with ironstone, ...	5	1	10
Black shale,.....	0	2	0
Dark cold earth,.....	0	1	3
Calliard, ...	1	1	2
Stone bind,.....	1	2	7
Calliard, ...	0	0	9
Strong stone bind, ...	1	2	7
Dark streaked stone, ...	5	2	7
Strong stone bind, ...	1	0	0
Carried forward,.....	83	2	7

	Yds.	Ft.	In.
Brought forward, ...	83	2	7
Ironstone balls, ...	0	0	9
Blue metal, ...	0	0	9
Coal, ...	0	0	8
Dark earth, ...	0	0	4
Strong gritty spavon, ...	0	2	9
Calliard, ...	0	1	0
Strong stone, ...	1	1	11
Soft blue metal, ...	2	0	10
Black earth, ...	1	0	10
Strong stone, ...	2	2	5
Blue soapy metal, ...	4	0	5
Black earth, ...	0	0	10
Dark earth, ...	1	0	4
Strong black drub, ...	0	2	9
Black shale, ...	0	1	0
Stone coal, ...	0	1	4
Black coal, ...	0	1	8
Soft dark earth, ...	0	0	2
Sharp earth, ...	0	1	6
	102	0	10

SECTION AT BOWLING.

	Yds.	Ft.	In.
Soil, ...	0	2	6
Raggy stone, ...	2	0	6
Brown shale, ...	1	1	2
Blue shale, ...	0	2	0
Ironstone, ...	0	0	0½
Blue shale, ...	0	0	9
Ironstone, ...	0	0	0¾
Blue shale, ...	0	1	8
Ironstone, ...	0	0	1½
Blue shale, ...	0	1	6
Ironstone, ...	0	0	1½
Carried forward, ...	6	1	5¼

	Yds.	Ft.	In.
Brought forward, ...	6	1	5¼
Blue shale, ...	0	1	4
Ironstone, ...	0	0	2½
Blue shale, ...	0	0	6
Ironstone, ...	0	0	1½
Blue shale, ...	0	1	1
Ironstone, ...	0	0	2
Blue shale, ...	0	1	3
Ironstone, ...	0	0	1
Blue shale, ...	0	0	10½
Ironstone, ...	0	0	1
Blue shale, ...	0	0	4
Ironstone, ...	0	0	1¼
Blue shale, ...	0	1	3
Ironstone, ...	0	0	2
Blue shale, ...	0	1	0
Ironstone, ...	0	0	2
Blue shale, ...	0	0	5
Ironstone, ...	0	0	1½
Blue shale, ...	0	1	0
Ironstone, ...	0	0	1½
Blue shale, ...	0	0	4
Ironstone, ...	0	0	1
Coal band, ...	0	0	2½
Soft seat earth, ...	0	2	0
Seat stone, ...	1	1	0
Raggy stone, ...	2	0	10
Hard stone, ...	0	1	8
Ironstone, ...	0	0	1
Blue shale, ...	0	2	1
Ironstone, ...	0	0	0¾
Blue shale, ...	0	2	1
Second coal band, ...	0	0	5½
Soft seat earth, ...	1	1	0
Ironstone, ...	0	0	2
Soft seat earth, ...	1	0	4
Black shale, ...	1	0	7
Ironstone, ...	0	0	2
Soft seat earth, ...	0	0	0
Carried forward, ...	20	0	11¾

	Yds.	Ft.	In.
Brought forward, ...	20	0	11¾
Coal band,	0	0	5
Soft seat earth,	1	1	0
Blue shale,	1	0	9
Hard stone,	0	1	2
Hard blue shale,	1	0	1
Stone,	0	0	8
Blue shale,	0	1	7
Hard stone,	0	0	8
Blue shale,	0	2	5
Stone,	0	1	0
Black shale,	0	2	11
Stone,	0	0	9
Black shale,	2	1	5
Ironstone,	0	0	1
A grime of coal,	0	0	0¼
Black shale,	0	1	4
Black bed quarry,	0	0	6
Black shale,	0	0	10
Ironstone,	0	0	1
Black shale,	0	1	2
Ironstone,	0	0	1
Black shale,	0	1	0
Ironstone,	0	0	1
Black shale,	0	0	11
Ironstone,	0	0	1
Black shale,	0	0	9
Ironstone,	0	0	1½
Black shale,	0	0	6
Ironstone,	0	0	2½
Black shale,	0	1	2
Ironstone,	0	0	3
Black shale,	0	0	7
Ironstone,	0	0	1
Black shale,	0	0	8
Ironstone,	0	0	2
Roof shale,	0	0	7
Black bed coal,	0	2	3
Spavon or soft seat earth,	0	0	5
Carried forward, ..	34	2	9

	Yds.	Ft.	In.
Brought forward,	34	2	9
Hard seat,	1	1	0
Seat stone,	1	2	0
Blue shale,	0	1	10
Hardstone,	1	1	6
Raggy stone,	2	0	10
Blue shale,	0	1	0
Stone,	0	2	0
Blue shale,	2	0	0
Thick stone,	6	1	0
Strong blue shale,	4	1	0
Ironstone,	0	0	2
Blue shale,	0	2	10
Ironstone,	0	0	3
Blue shale,	0	2	3
Ironstone,	0	0	3
Soft blue shale,	1	1	0
Ironstone,	0	0	1
Coal band,	0	0	2
Soft seat earth,	1	1	8
Seat stone,	0	2	0
Strong rag or shale,	5	2	0
First stone, called the threefold,	0	0	2
Rag or shale,	0	1	0
Second stone, called the threefold,	0	0	6
Rag or shale,	0	2	0
Third stone, called the threefold,	0	0	3
Brown earth,	3	1	1
White earth,	1	0	0
Better bed coal,	0	2	3
	73	1	10

SECTION TO THE

ROYDS AND LOW-MOOR SEAMS,

AT THE LOW-MOOR IRON WORKS, NEAR BRADFORD.

	Yds.	Ft.	In.
Argillaceous sandstone, ...	8	0	0
Grey bind, ...	6	0	0
Black shale,.....	0	0	9
A coal band, ...	0	0	9
Seat stone, ...	0	1	0
Blue bind, ...	13	0	0
Ironstone measures in which are seven thin beds of ironstone, ...	2	1	6
Black shale,.....	0	1	6
A coal band, ...	0	1	0
Blue bind, ...	2	0	0
Argillaceous sandstone ...	1	1	0
Blue bind, ...	8	0	0
The three coal bands, ...	0	1	6
Blue bind, ...	0	1	0
Sandstone, ...	0	1	0
Blue bind, ...	2	1	6
Argillaceous sandstone, ...	2	0	0
Blue bind, ...	4	0	0
Black shale, in which are five beds of ironstone, two thin and three worked for the furnace, ...	1	1	6
The black bed of coal, Royds coal,.....	0	2	10
White clay,.....	0	1	6
Argillaceous sandstone, ...	0	2	0
Blue bind, ...	8	0	0
Argillaceous sandstone, called thick stone,.....	9	0	0
Blue bind, ...	7	0	0
Carried forward,.....	79	2	4
Brought forward,.....	79	2	4
Blue bind, in which is four thin beds of ironstone,	2	0	0
Black shale,.....	0	0	6
A coal band, ...	0	0	4
Grey bind, ...	9	0	0
Alternations of sandstone and grey bind, ...	2	0	3
Black shale,.....	0	1	6
Low-Moor coal, ...	0	2	3
	94	1	2

SECTION THROUGH THE

LOW-MOOR COAL,

AT POTTER'S ALMS HOUSES, IN LEEDS.

	Yds.	Ft.	In.
Earthy loose sandstone,...	3	0	0
Argillaceous sandstone, ...	15	0	0
Yellow bind, ...	12	0	0
Blue bind, ...	3	0	0
Blue shale, containing ironstone, ...	1	2	6
Black shale,.....	0	1	6
Low-Moor coal, ...	0	1	6
Potter's clay, containing variolariæ, ...	1	0	0
White earth, ...	1	2	0
White siliceous sandstone, alternating with white earth, ...	3	0	4
Blue bind, ...	12	0	0
	53	1	10

At a boring about two hundred yards from the above, and continued to the flagstone, the measures below the Low-Moor coal were principally blue bind, about forty yards thick.

SECTION TO THE

LOW-MOOR COAL,

AT ROUNDHAY, NEAR LEEDS.

	Yds.	Ft.	In.
Yellow bind,	5	0	0
Blue shale, containing ironstone,	3	0	0
Black shale,	0	2	0
Low-Moor coal, (beneath the coal, potter's clay,)	0	1	4
	9	0	4

SECTION FROM THE UPPER SURFACE OF THE FLAGSTONE, PASSING THROUGH THE

HALIFAX OR PECTEN COAL,

TO THE MILL-STONE GRIT AT CATHARINE SLACK, NEAR HALIFAX.

	Yds.	Ft.	In.
Flagstone,	10	0	0
Raggy stone and shale alternating,	50	0	0
Coal,	0	0	6
Seat earth,	0	2	0
Black shale,	31	0	0
Coal,	0	1	0
Seat earth,	0	2	0
Shale,	11	0	0
Coal,	0	0	9
Seat earth,	0	2	0
Calliard, (hard sandstone,)	3	0	0
Coal,	0	0	2
Black shale,	5	0	0
Strong rag, (sandstone,)	18	0	0
Shale,	6	0	0
Hard stone bind,	0	1	0
White earth,	0	2	0
Carried forward,	137	2	5
Brought forward,	137	2	5
Shale, containing pecten papyraceus,	0	1	0
Coal,	0	2	3
Hard calliard, containing pyrites,	0	0	9
Seat earth,	2	2	0
Grey shale,	4	0	0
Black shale,	6	0	0
Black shale, containing fossil shells,	0	0	3
Coal,	0	1	0
Seat earth,	0	1	0
Stone,	1	1	0
Shale and hard binds,	10	1	6
Black stone,	0	2	0
Coal,	0	1	8
Seat earth,	0	2	0
Stone,	4	0	0
Shale,	27	0	0
Coal,	0	0	6
Seat earth,	0	1	0
Shale and Rag,	10	0	0
Mill stone grit,	0	0	0
	207	2	4

SECTION TO THE

HALIFAX OR PECTEN COAL,

AT RAWDEN.

	Yds.	Ft.	In.
Calliard,	3	1	0
Coal,	0	0	4
Sandstone, with partings of shale,	4	0	0
Brown raggy sandstone,	4	0	0
Lifts of sandstone, fourteen inches thick, with			
Carried forward,	11	1	4

	Yds.	Ft.	In.
Brought forward,.....	11	1	4
partings of shale, two inches thick, ...	6	0	0
Blue shale, ...	6	0	0
Sandstone, ...	2	0	0
Blue shale, ...	18	0	0
Black shale, containing an ammonite, ...	0	0	3
Black shale, containing P. papyraceus,.....	0	1	0
Coal, ...	0	1	4
Seat of the coal, (calliard,)	2	0	0
Measures of sandstone and shale, ...	8	0	0
Coal, ...	0	0	10
	54	1	9

SECTION TO THE

HALIFAX OR PECTEN COAL,

AT

MOOR-ALLERTON, NEAR LEEDS.

	Yds.	Ft.	In.
Clay, ...	2	0	0
Shale, containing an ammonite in its lower part, ...	1	0	0
Shale, containing P. papyraceus,.....	0	1	0
Coal, ...	0	0	4
Calliard, ...	2	0	0
	5	1	4

EXPLANATION OF THE PLATES.

MR. NUNNELEY'S PAPER UPON LIMACES, PAGE 41.

PLATE I.

Fig. 1. Species 1. Cochlea Agrestis, C. Viarum, C. Vulgaris, Swam: Bib, Naturæ, Vol. I. Page 162; Vol. II. Plate 4.
Limax rufus, Linn:
Limace rouge, Lamk: Anim; S; vert; Tome 6.
Limax ater, Limax succineus, Müller. Verm; Hist:
Limax rufus, Draparn: Hist; des Moll;
Limax subrufus, Lister.
Limace rousse, Cuv: Ann; du Mus: Tome 7.

Species 2. Cochlea nuda; C. domestica, Swam: Bib; Nat; Vol. I. Page 158; Vol. II. Plate 8.
Limax maximus, Linn; Syst; Nat;
Limax cinereus, Lister, Phil; Trans; for 1674.
Limax anticorum, Ferus; Hist; des Moll;
Limace grise, Lamk: Anim; S; Vert; Tome 6.
Grande Limace grise tachetée, Cuv: Annal; du Mus; Tome 7.
Limax maculatus.

Species 3. Limax variegatus, Drap: Hist; des Moll;
Limace blonde des caves.
Limace tachetée.

Species 4. Limax agrestis, Linn: Lam: Anim; s; ver; Tome 6, Page 50. Flem: Brit; Anim; Page 256.
Limax reticulatus, Müller.
Limax filans, Hoy.

EXPLANATION OF THE PLATES.

Plate II.

Fig. 1. First Species.

Muscles and last portion of intestine, the animal is placed upon its dorsum, the foot being cut open and fastened back.

a. a. Cut edges of foot.

b. Shield seen through the other parts, the heart and mucous organ being in the centre.

c. The last portion of the intestine inflated.

d. Buccal mass, with

e. Its retractor muscle.

f. Retractor muscle of right tentaculum.

g. Ditto of left tentaculum.

h. h. Small muscular slips sent to near the buccal mass from the tentacular fasciculi.

i. i. The two tentacula on each side.

Fig. 2. Second species.

a. a. Cut edges of the foot.

b. Shield; heart and organ of mucosity in the centre of it.

c. c. The last portion of the intestine, forming a loop which runs down the cloak.

d. Buccal mass.

e. Common retractor muscle, which divides into three branches; one

f. For the buccal mass; and, two

g. g. For the tentacula, which latter, as in the first species, give off a slip on each side to the integuments near the buccal mass.

h. The retractor muscle of penis.

i. The penis which passes above the muscular fasciculi of the buccal mass and left tentaculum, but between those of the right tentaculum.

j. j. Tentacula on each side.

Fig. 3. Third Species.

The letters refer to the same parts in this as in the preceding figure; but in this Limax there is only a single process from the intestine, and not a loop, running down the cloak as in the last.

Fig. 4. Fourth species. Natural size.

a. a. Cut edges of foot.

b. Shield, with the mucous organ and heart in the centre.

c. Last portion of the intestine.

d. Buccal mass.

e. Common retractor muscle, arising by two roots, and dividing into two fasciculi; the one,

f. Which again divides to form the retractor of the buccal mass; and the other which also divides into two parts, *g. g.* for,

h. h. the tentacula on each side.

The penis, with its muscle, is shown in Plate VII.

Fig. 5. Magnified view of an upper tentaculum, cut off while the Limax was crawling, and then completely inverted to show its structure.

a. The inner surface of the inverted integuments, showing its minute granules and the delicate fibres continued from the retractor muscle to the head of the animal. It is by these fibres that the tentaculum is projected.

b. The integuments, cut at the point where they are continuous with those covering the head.

c. The retractor muscle, near its junction with the integumental portion of the tentaculum, where it becomes hollow and encloses the optic nerve, cut open, its fibres are seen not to terminate abruptly, but some of them are continued on the cutis, as above stated.

d. The optic nerve terminating in an enlarged bulbous mass, raised and completely turned forwards, in order to show

e. The globular crystalline lens and vitreous humour enclosed in the choroid capsule, which is partially embedded in the nervous mass.

Fig. 6. A greatly enlarged view of the globe of the eye, showing the circular opening in the fore part of the choroid membrane.

Plate III.

Fig. 1. Enlarged view of tooth in first species.

Fig. 2. Enlarged view of tooth in second, third, and fourth species.

Fig. 3. Preparation taken from a large specimen of the first species after it had been immersed in strong spirit. The cloak has been cut away at its junction with the foot, and all the viscera, with the exception of the buccal cavity and œsophagus, removed.

a. a. The cut surface of the contracted envelope, showing in the centre of the foot

b. b. The two longitudinal muscles projecting as raised lines within the cavity.

c. The buccal cavity laid open.

d. The tongue.

e. The small projecting cylindrical body placed between the two rami of the tongue.

f. The œsophagus laid open, showing the longitudinal folds into which the lining membrane is thrown.

Fig. 4. Limax placed upon the foot, the shield and anterior part of the envelope having been removed.

a. a. Cut surface of integuments.

b. Buccal mass.

c. Portion of small cylindrical body projecting above the œsophagus.

d. Stomach.

e. e. Salivary glands.

f. f. Salivary ducts opening into buccal cavity.

g. Intestine.

Fig. 5. Stomach, intestine, and biliary ducts filled with mercury.

a. Stomach ending in

b. A large round cul de sac.

c. Commencement of intestine.

d. Posterior lobe of liver, with large biliary duct filled with mercury, and opening into the stomach opposite to the pylorus.

e. Anterior lobe of liver with its duct, also filled, and opening into the stomach anterior to the pylorus.

Fig. 6. A large Limax ater cut open along the foot; the viscera are unfolded and separated from each other.

a. a. The thick contracted foot.
b. Buccal mass.
c. Stomach commencing by the narrow œsophagus.
d. d. Portions of intestine.
e. Posterior lobe of liver.
f. Anterior lobe.
g. Ovary.
h. Oviduct.
i. Testicle.
j. j. Uterus and Vagina.
k. Cloaca.
l. Origin of Aorta, which immediately divides into two principal branches.
m. Anterior trunk, which gives off several branches, and is lost about the neck and buccal mass.
n. Larger posterior trunk, which gives off an immense number of branches (only a small part of which are here shown) to the stomach, intestine, and liver.

Plate IV.

Fig. 1. A Limax ater, cut open along the foot and spread out, all the viscera have been removed, and the venous system injected with mercury.

a. a. The two venæ cavæ, forming a vascular circle, round
b. The pulmonary cavity, nearly in the centre of which is seen
c. The organ of mucosity, and within the ring of this latter is placed
d. The heart, enclosed in its pericardium.

Fig. 2. This and the three following figures show the position of the heart and the pulmonary vessels; this figure shows the vessels on the upper surface of the pulmonary cavity in the first species.

a. a. Venæ cavæ forming the vascular circle, from whence the pulmonary vessels arise.
b. Genital orifice.
c. Respiratory orifice.

d. Bristle showing direction of rectum.
e. Pulmonary vessels, most numerous on the *left* side, (the right as seen in this figure.)
f. Mucous ring.
g. Auricle.
h. Ventricle.

Fig. 3. *a.* Convex dorsum of a Limax of the first species.
b. b. Cut surface from whence the shield has been removed.
c. Respiratory orifice, having a bristle introduced to show the course of the rectum.
d. d. Vessels spread upon the inferior surface of the pulmonary cavity, mounting upon the sides of
e. The mucous ring to expand on the left side into
g. The auricle, which latter opens into
f. The ventricle.

Fig. 4. Shows the vessels upon the upper surface of the respiratory cavity in the second and third species. The letters *a a*, *e*, *e e*, *f*, *g*, *h*, refer to the same parts as the corresponding letters in fig. 2.

Fig. 5. Shows the vessels upon the lower respiratory surface in second and third species, the letters correspond with those of fig. 3.

Plate V.

Fig. 1. Nervous System. Limax ater; the animal has been cut open along the centre of dorsum from the shield to the tail; the shield has been cut from its attachment on the left side and turned over to the right; all the viscera removed.
a. The inner surface of the shield.
b. The mucous ring and heart.
c. The origin of the left tentacular muscle cut in turning back the shield.
d. Its continuation to join
e. The left tentaculum.
f. The muscle on the right side, passing to join
g. The right tentaculum.
h. Buccal mass, arising from which is the cut œsophagus seen projecting through

i. The nervous ring, which contains
j. The supra-œsophageal ganglion, and
k. The infra-œsophageal ganglion. A bristle is inserted between the two layers of which it is composed. The following branches arise from the supra-œsophageal ganglion.
l. l. The large optic nerves to the upper tentacula.
m. m. Two smaller branches to the lower tentacula. And
n. n. Two branches lost near the lips.

Fig. 2. A Limax of the third species, cut open along the foot and laid upon the cloak. None of the viscera have been removed.
a. a. Large tentacula.
b. Buccal mass.
c. Stomach.
d. Intestine.
e. e. Liver.
f. f. Uterus.
g. A slip of whalebone placed under the infra-œsophageal ganglion.
h. Slip of whalebone placed under the nerves arising on each side of the ganglion.
i. i. The two large posterior nerves, the same as seen in fig. 1.

Fig. 3. A magnified view of the under surface of the infra-œsophageal ganglion in the first species.

Fig. 4. Ditto in the second, third, and fourth.

Fig. 5. Organs of generation in the first species; the animal has been cut open along the foot, and all the other parts are removed.
a. The ovary.
b. Oviduct.
c. Testicle.
d. d. The convoluted uterus and vagina uncoiled.
e. e. The narrow portion of the testicle, or epididymis, terminating in
f. The vas deferens, which opens into
h. The penis.
i. The vesicle.
j. The cloaca.
k. The retractor muscle of the cloaca.

Fig. 6. Organs of generation in the same species, separated from each other, and the cloaca laid open.

a. Uterus.

b. Epididymis.

c. Vas deferens.

d. Penis opening into the cloaca by

e. A nipple-like projection.

f. The vesicle, opening into the cloaca close to the penis.

g. Two large projecting lips, which nearly fill up the cavity of the cloaca, and between which is seen the opening into the vagina.

1, 2, 3, bristles introduced into the penis, vesicle, and uterus.

Plate VI.

Fig. 1. Organs of generation in the second species, the animal has been cut open along the foot, and all the viscera removed, this figure shows the wasted or shrunken condition of the testicle and uterus, which is sometimes found in this species.

a. The ovary, (it has been represented rather larger than it should have been in all these three figures.)

b. The oviduct.

c. Shrunken testicle.

d. Shrunken uterus.

e. The vagina.

f. j. Epididymis terminating in

g. The vas deferens, which opens into

h. The large penis.

i. The retractor muscle of penis.

j. The small vesicle.

Fig. 2. Organs of generation in the same species partially laid open; in this the testicle and uterus are seen of their usual size. The letters as far as *h.* refer to the same parts as in the preceding figure.

h. Penis cut open, and flaps pinned back, to show

i. The longitudinal projection occupying its cavity.

j. The retractor muscle of penis.

k. The vesicle.

l. The point of junction of the penis, vagina, and vesicle, at the common external orifice, cut open and thrown back.

1. 2. 3. Bristles introduced through the common genital orifice into the penis, vesicle, and vagina.

Fig. 3. Organs of generation in the third species. The letters refer to the same parts as in fig. 1.

Fig. 4. A magnified view of the ovary in the third species, to show the clusters of ova, of different sizes, enclosed in a thin transparent membrane.

Plate VII.

Fig. 1. Organs of generation in the third species partially laid open. This figure is taken from a preparation which had been for some time immersed in very diluted spirit, by which means the mucous walls of the uterus swell and dilate to a large size, while the vaginal portion of the tube does not increase in size.

a. Ovary.

b. Oviduct.

c. Testicle.

d. d. The uterus cut open to show its swollen and dilated walls terminating abruptly in

e. The thin membranous vagina, also laid open, through which is seen

f. The epididymis.

g. Vas deferens.

h. The penis partially cut open to show the small projection within its cavity.

i. The retractor muscle.

j. The vesicle.

1. 2. Bristles inserted from the common external orifice into the penis and vagina.

3. Bristle passed from the vagina into the vesicle.

Fig. 2. The organs of generation in the fourth species much magnified; the animal is cut open along the foot, and the other viscera are removed.

a. The organ of mucosity and heart seen under the diaphragm.

b. The ovary.
c. Oviduct.
d. e. Uterus and vagina.
f. The bilobed testicle.
g. Its narrow portion, terminating in
h. The Vas deferens, which opens into
i. The penis.
j. Retractor muscle of the penis.
k. Buccal mass thrown forwards.

Fig. 3. Shows the penis cut open and much magnified.
a. a. The walls of the penis cut and turned back.
b. Septum which in a great measure separates the interior cavity of the penis into two parts.
c. The projecting body which occupies the upper division.
d. That which occupies the lower division. The other parts are the same as in fig. 2.

Fig. 4. Magnified view of ovary and radicles of oviduct in this species.

MR. JOHN HEY'S PAPER ON ROMAN COIN MOULDS, PAGE 80.

PLATE VIII.

The plain black line indicates the route from Cambodunum to Calcaria, corresponding with the 2nd Iter of Antoninus; and the dotted line, the supposed one from Cambodunum to Legeolium, passing by the Camp at Kirklees and the Street of Ossett and Dewsbury.

The Drawings in the corner show the mode in which the Coin Moulds were used; a double column of the moulds being enclosed in a covering of Clay so as to leave a funnel-shaped opening at the top, into which the metal was poured. They are copied from Mr. Artis.

MR. TEALE'S PAPER ON ACTINIA, PAGE 91.

PLATE IX.

Figs. 1 and 2. Actinia Coriacea. Natural size.

Fig. 3. Portion of the external envelope magnified, showing the tubercular eminences and their central aperture.

PLATE X.

Fig. 1. Actinia Coriacea. Continuity of the skin and stomach represented.

Fig. 2. The stomach spontaneously everted.

a. A circular space, where the stomach is deficient inferiorly, at which part it communicates with the interseptal spaces.

b. c. Two deep folds in the stomach, which divide the animal into two lateral halves.

Figs. 3, 4, 5, 6. The muscles of the vertical leaflets.

Fig. 7. The circular muscles of the sides, seen on turning aside two of the leaflets, and exposing the portion of skin situated between their insertions.

a. The fibres constituting the circular order of muscles.

Fig. 8. The muscles of the base, seen on turning downwards two of the leaflets, and exposing the portion of skin situated between their lines of insertion.

a. The fibres which form part of a circular series of muscles of the base.

b. The radiating fibres of the base.

Figs. 9 and 10. Tentacula magnified, exhibiting their longitudinal and circular fibres.

Fig. 11. A portion of the outer lip magnified, having its two folds of skin dissected from each other, to expose the circular or sphincter muscle which they enclose.

PLATE XI.

Fig. 1. Actinia Coriacea. The ovary and vermiform filament represented on an enlarged scale.

a. The lip.
b. The mouth.
c. The stomach.
d. The muscular leaflet.
e. The ovary, or gemmiferous organ.
f. The mesentery connecting the ovary to the leaflet.
g. The vermiform filament gradually increasing in size as it passes downwards.
h. The mesentery connecting the vermiform filament to the ovary.
i. Termination of the vermiform filament in the stomach.

Fig. 2. A portion of ovary magnified and partially unfolded. The ova, or rather gemmules, in an advanced stage of maturity, most of them exhibiting a central depression, which indicates the situation of the oral aperture.

Figs. 3 and 4. Portions of the vermiform filament, with its mesentery magnified.

MR. TEALE'S PAPER ON ALCYONELLA, PAGE 116.

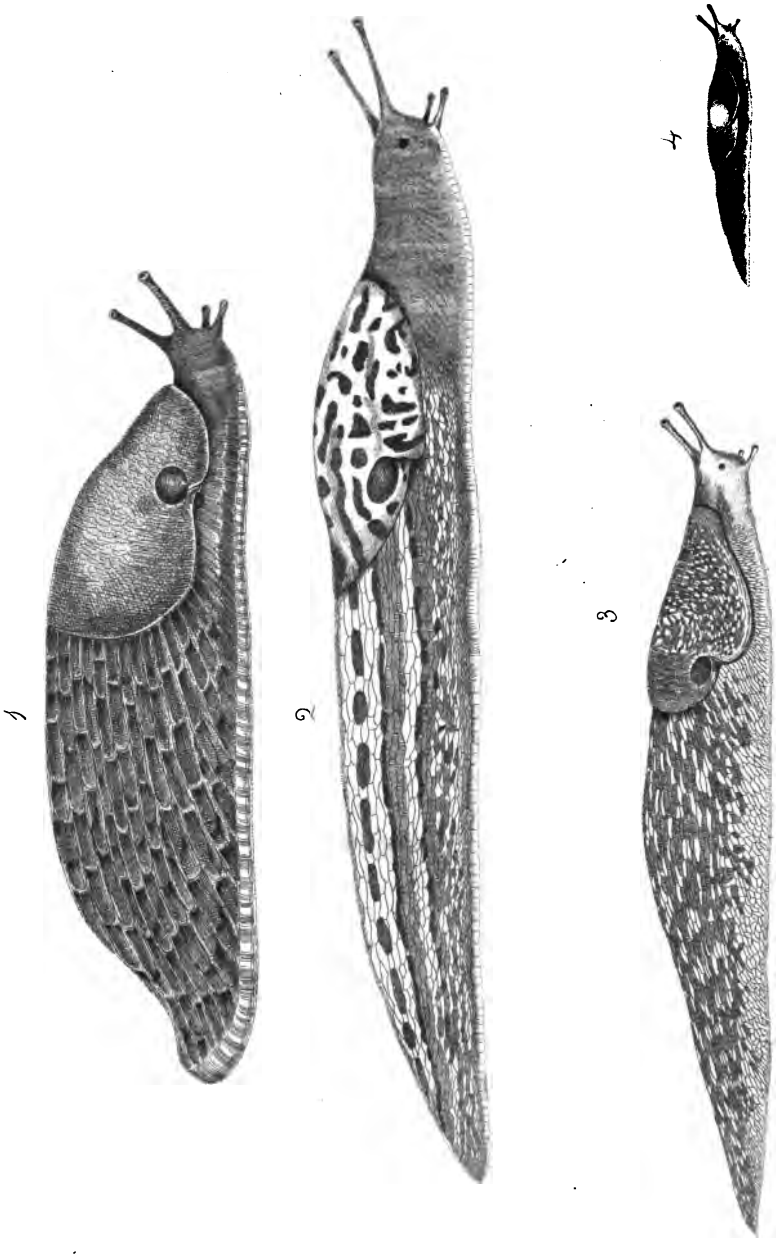
PLATE XII.

Fig. 1. Alcyonella Stagnorum. The polypiferous papilla exhibited.

Fig. 2. The polype expanded and protruding from the papilla.
a. The mouth.
b. The stomach.
c. The intestine.

Fig. 3. A polype of Alcyonella, with the digestive sac and ovary attached.
a. The polype.
b. The alimentary canal.
c. The ovary, attached to the neck of the papilla, and closed at its upper extremity. The ova are seen in different stages of maturity.

Plate 1



Henry Denny del et Sculp^t

Plate 2

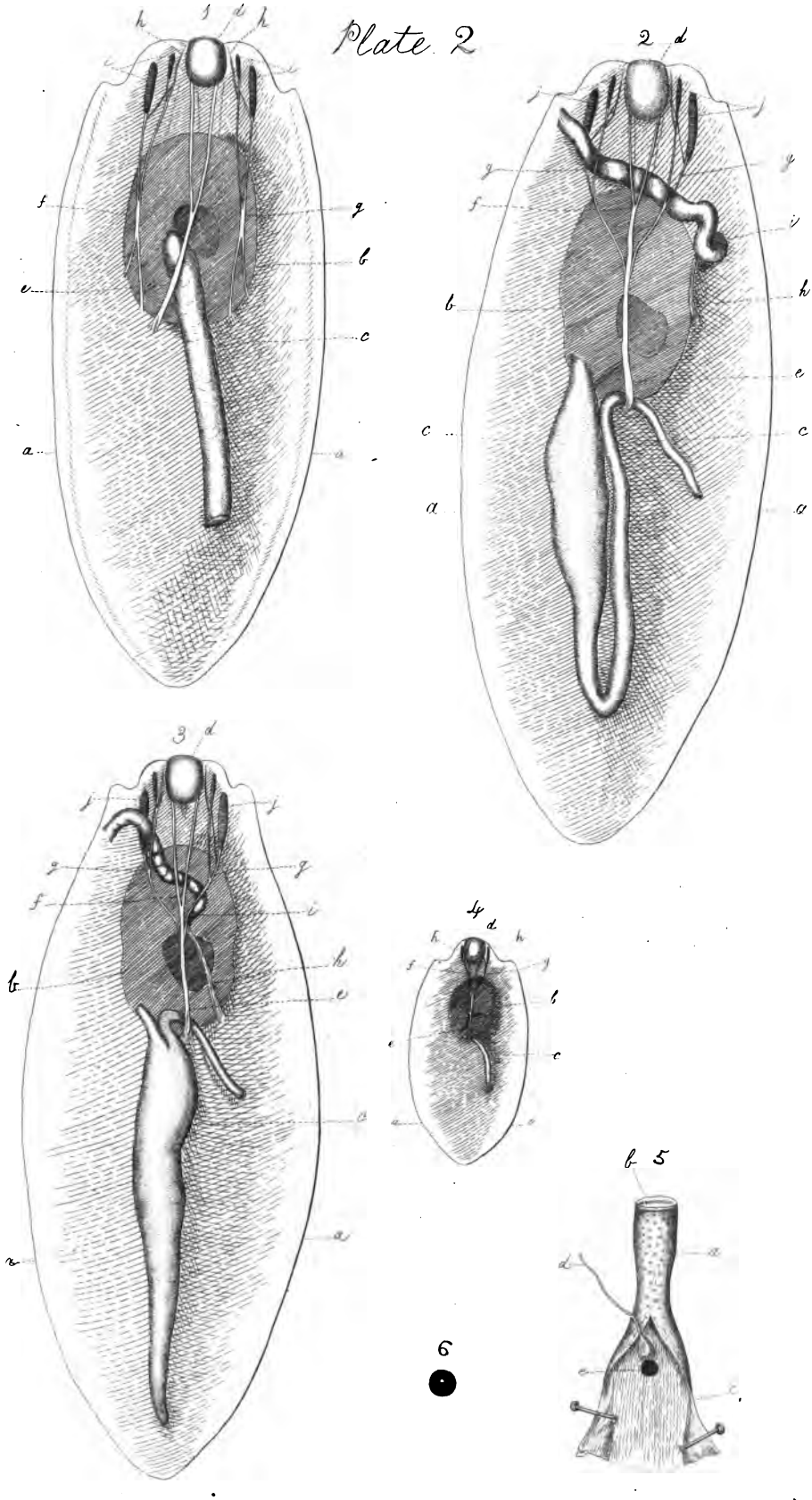
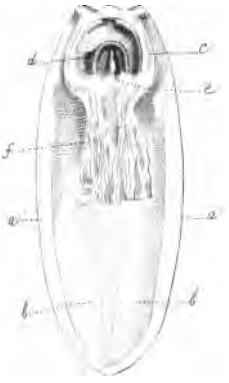


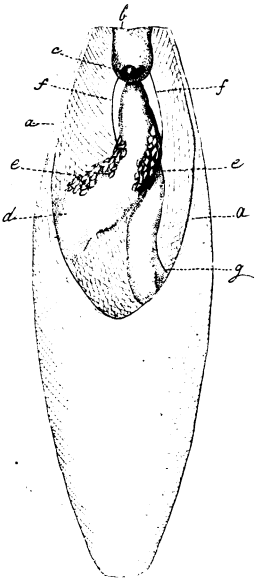
Plate 3

2

3

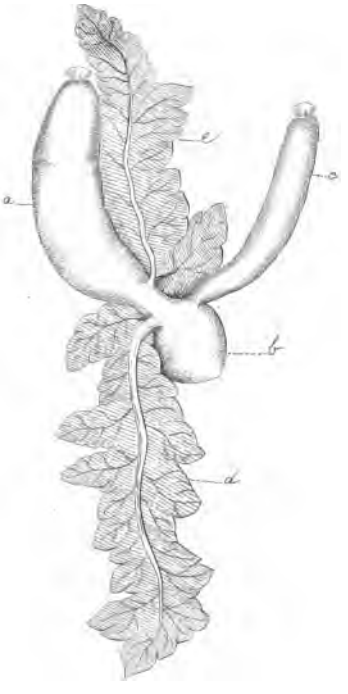


4

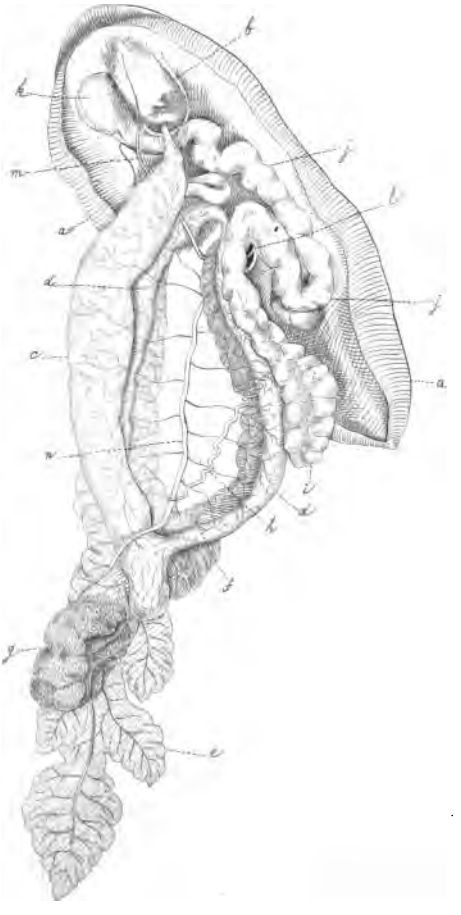


1

5



6



[illegible] del. et Sculpt

Plate 4

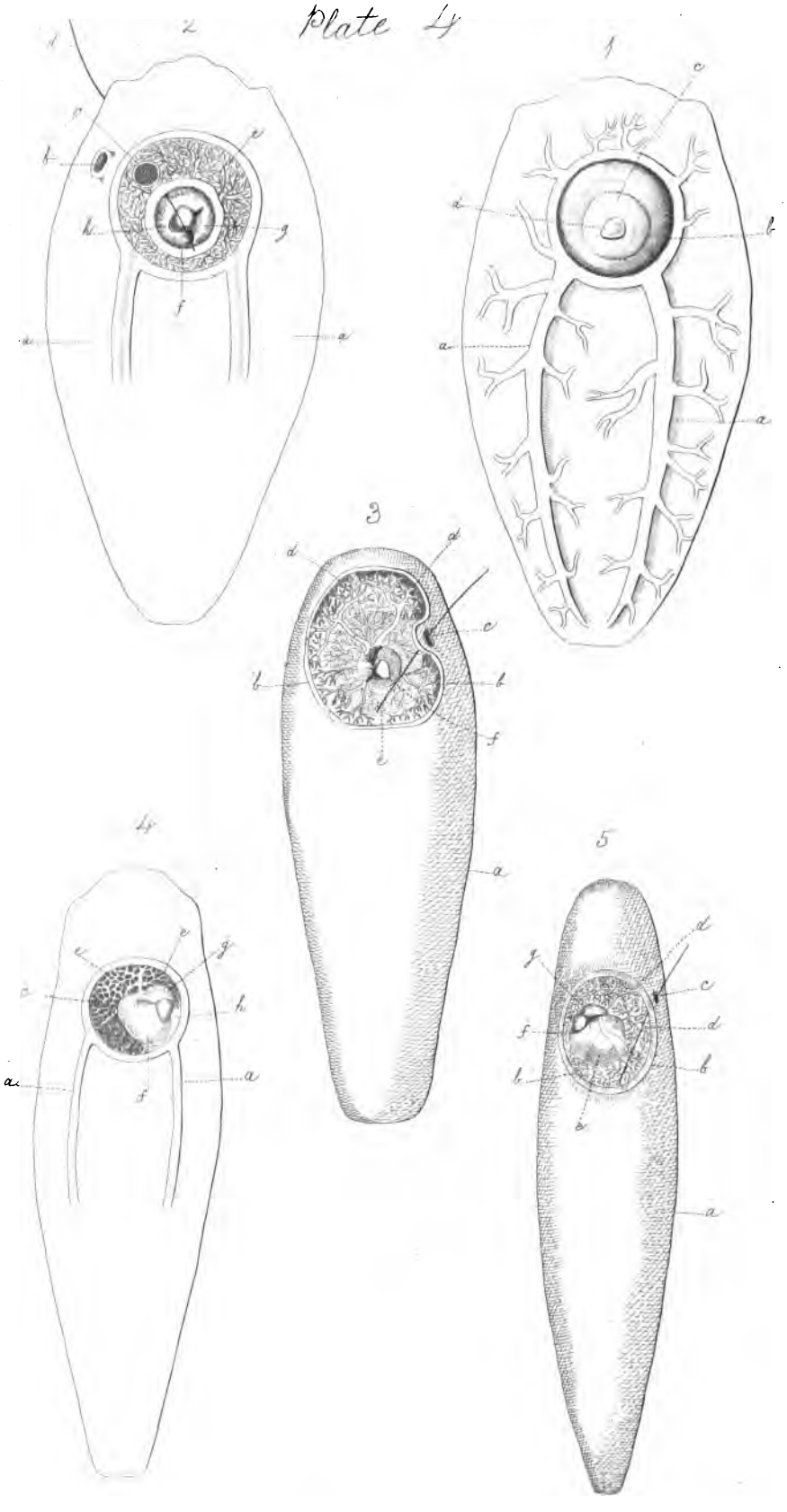
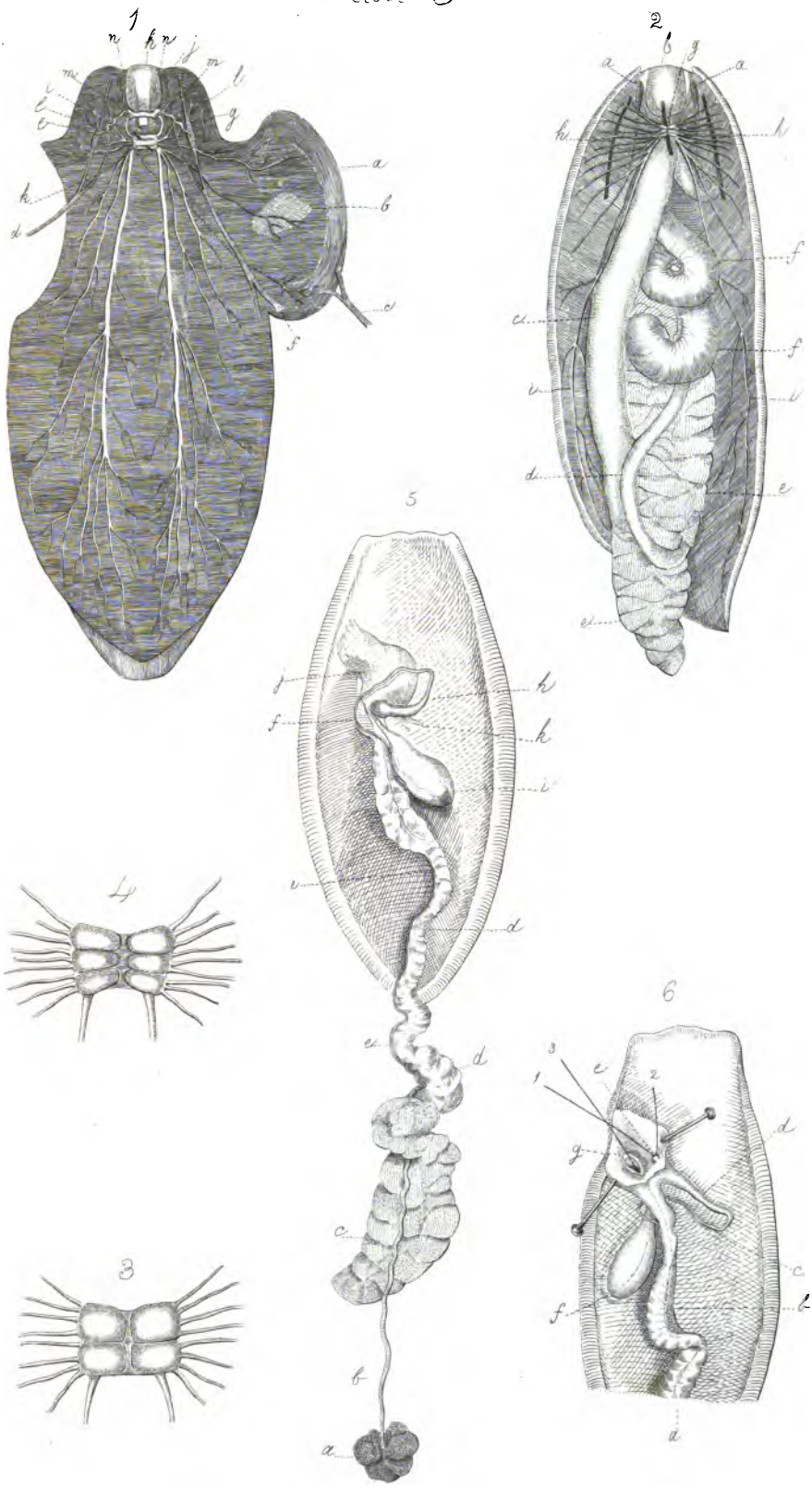
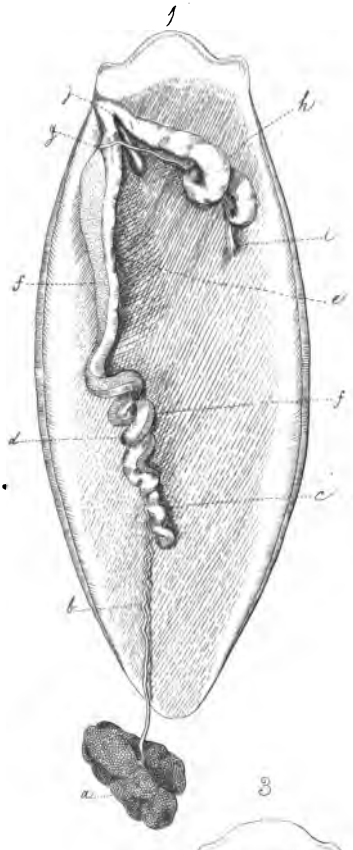


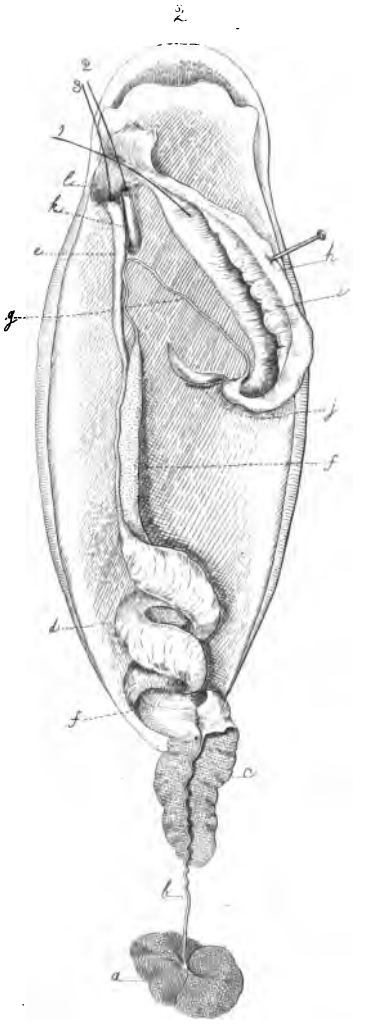
Plate 5



Henry Denny del et lith

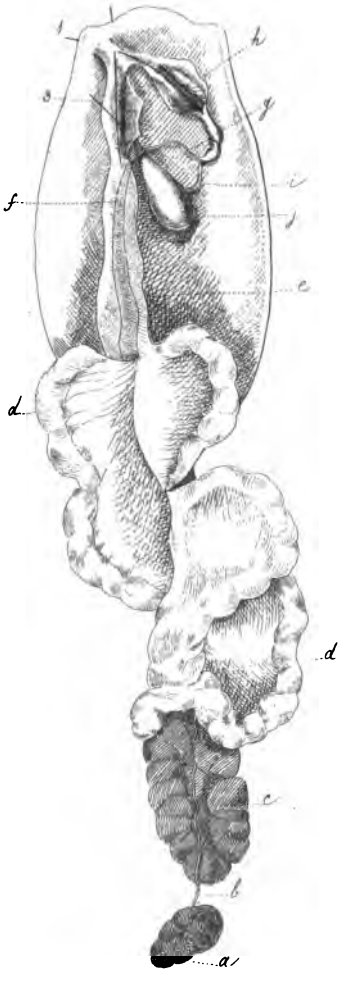
Plate 6

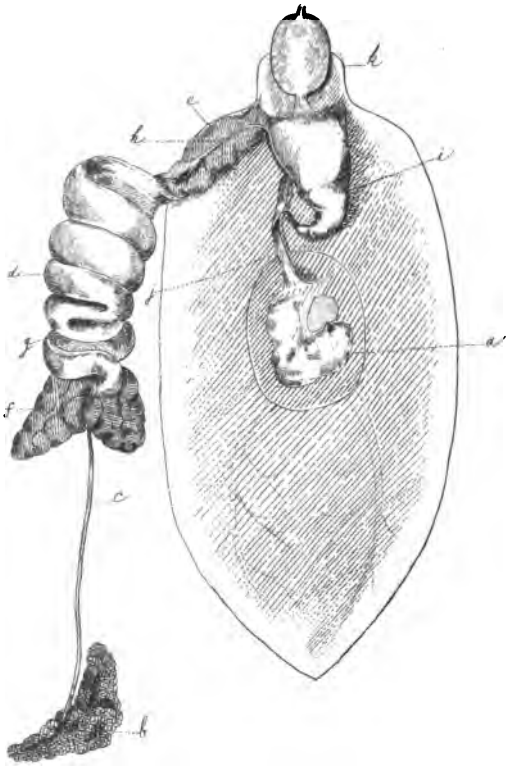


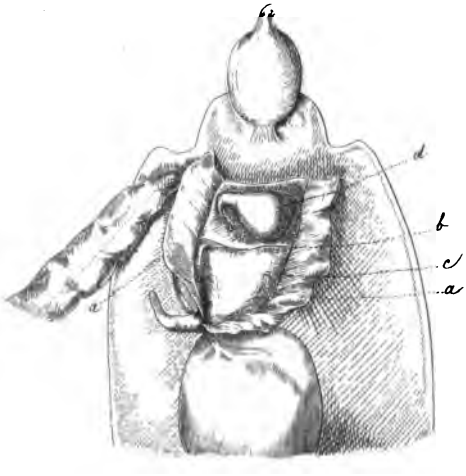


Henry Denny del. et Sculp.

Plate 7





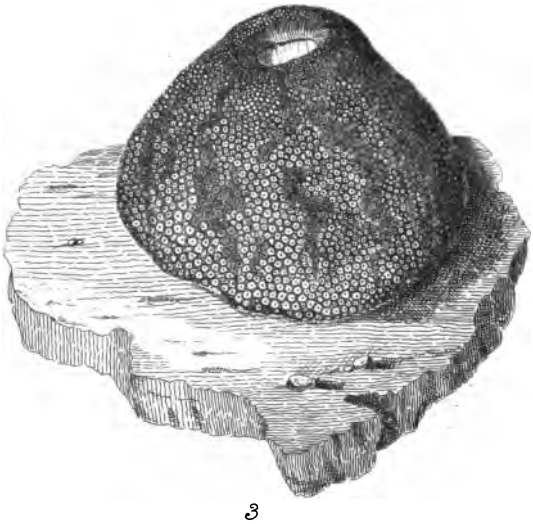


Henry Denny del.

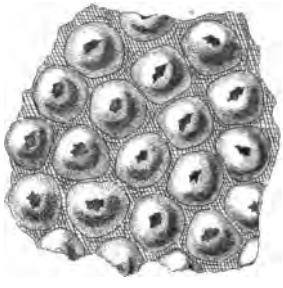
Henry Denny del. et Sculp.

Plate 9

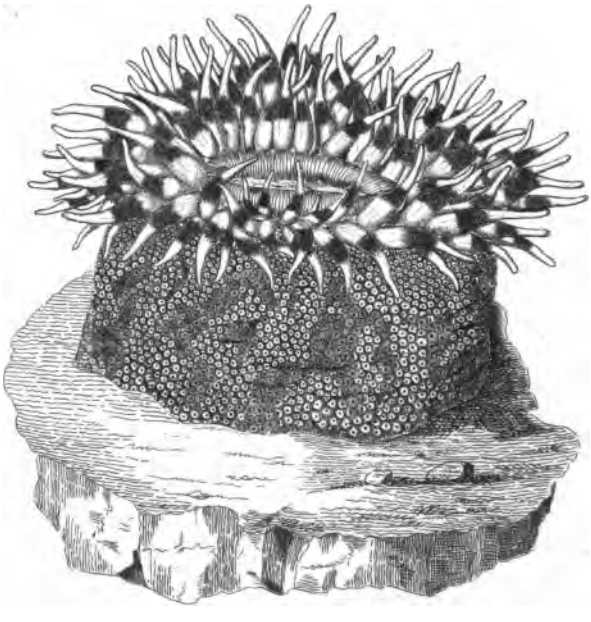
1



3



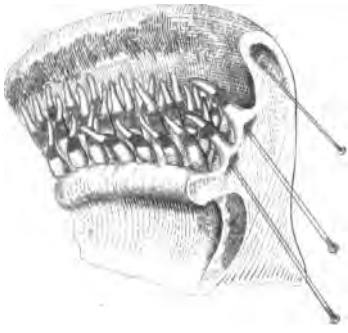
2



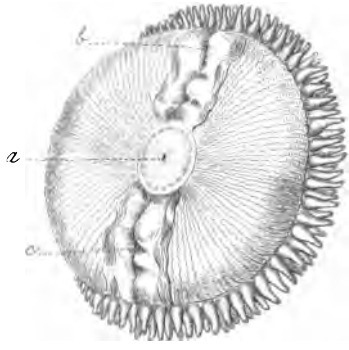
Henry Denny del. et Sculp.

Plate 10

1

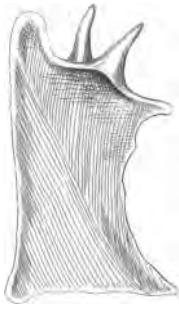


2

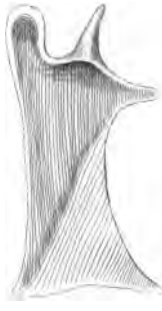


3

4

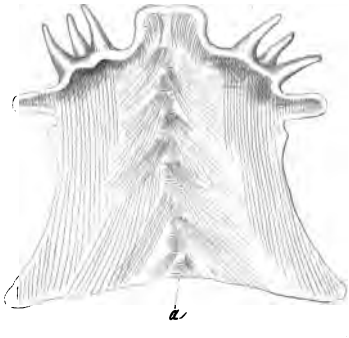


5

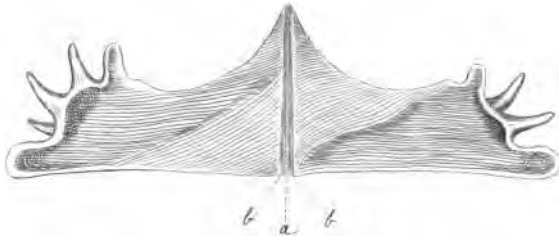


6

7



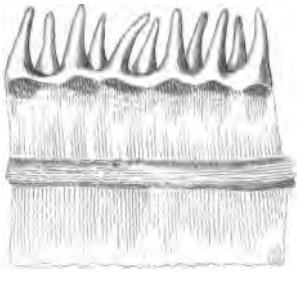
8



9

10

11

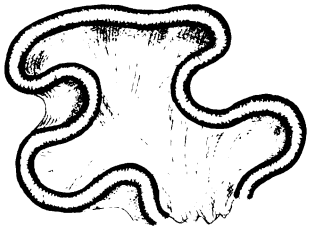


Henry Denny del.

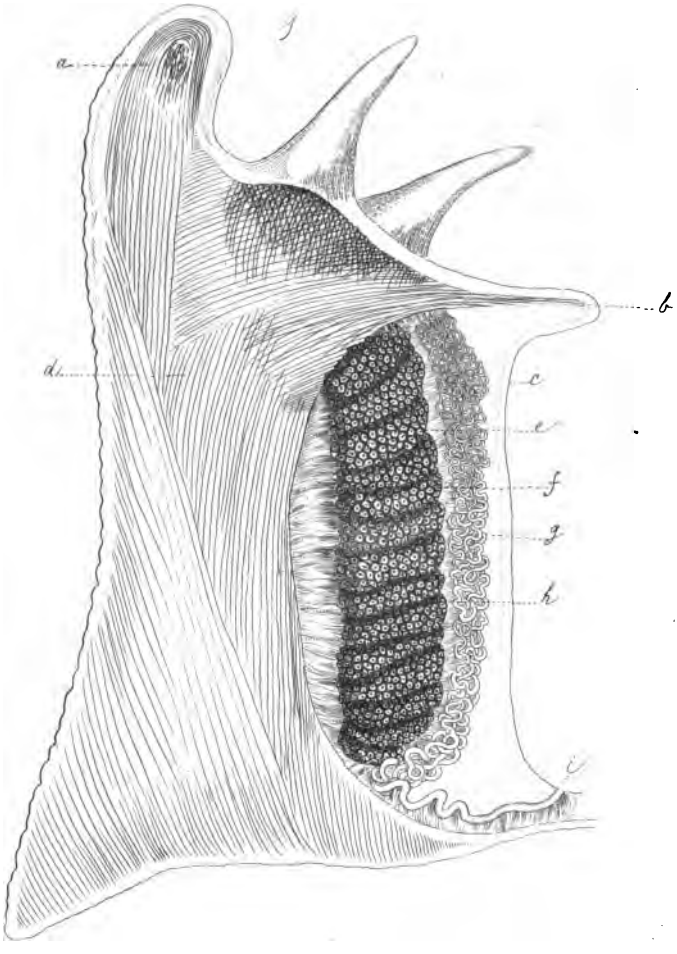
Plate 11

2

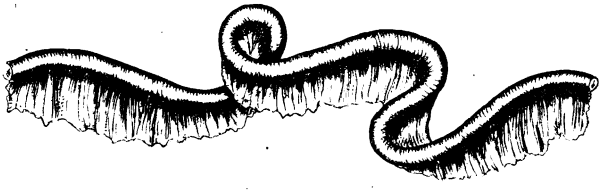
3



1



4



Henry Denny del et Sculp

Plate 12

J P Teale del^t

Henry Denny Sculp^t